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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

SEPTEMBER 4-22.

Fifth German Foundry Exhibition at Düsseldorf.

SEPTEMBER 9-12.

Institute of Metals:—Annual Autumn Meeting in Düsseldorf.

SEPTEMBER 10-13.

Iron and Steel Institute:—Autumn meeting at Newcastle-upon-Tyne.

SEPTEMBER 12-28.

Shipping, Engineering and Machinery Exhibition at Olympia, London.

Is the Cupola Doomed?

For a long time the cupola has been regarded as the heart of the foundry, and, too, as the one essential feature that distinguishes it from anything else. But it would be a mistake to regard this state of affairs as likely to persist for all time. Shaft furnaces have been and are used widely in metallurgical practice, in which the fuel required for smelting comes into actual contact with the metal to be smelted, although any such process must involve the disadvantages of contamination, oxidation, and heterogeneity. The cupola has, of course, certain peculiar advantages that arise from its elasticity in working. It can be used as a continuous furnace—that is to say, after melting has started metal can be withdrawn at any time. It can also be made temporarily discontinuous, either by holding the metal in the well or by shutting off the blast. Further, the cupola can be run for very short periods, and it is not very uneconomical to set it going for a small quantity of metal.

The one consideration which is likely to keep the cupola going in the face of rivals is its economy, and in this respect the shaft furnace invariably has the advantage, since direct saving results from the high thermal efficiency due to the direct transfer of heat into the metal. But if another furnace can be produced which will succeed in yielding metal with as little expenditure on fuel and as little cost on upkeep and depreciation, then the cupola seems almost bound to disappear, since its only other real advantage is the elasticity of working already referred to. For the cupola has this great drawback, that it places a limitation on quality. Even the most skilful of cupola operators cannot make the process yield metal above a certain level of quality, on account of the circumstances of melting, and a furnace in which the metal and the fuel are separated is bound to offer advantages with respect to quality—the feature that is being increasingly demanded by engineers. It must be remembered, however, that by no means all cupolas are operated to their limits in respect either of economy or quality, and the moment a rival appears in the field the users of the cupola will be stimulated more nearly to approach those limits.

One of the disadvantages of any alternative furnace is almost bound to be its capital cost. The cupola is the cheapest furnace for its capacity than can be constructed. In fact it is so cheap that the founder places himself at a disadvantage regarding it, for if he has made his own cupola or depreciated it to nothing no part of the cost of replacing it finds its way into the cost of the product. One of the main drawbacks to the replacement of out-of-date plant in the foundry trade is the lack of any reserve fund for development expenditure, and since new furnaces will inevitably involve a heavy capital outlay the drawback will apply particularly to them.

It is too early to estimate the real importance of the new furnaces that are being discussed in various quarters. But quite apart from their own merit or demerit, they will have a beneficial effect on founding, since the mere rumour of them will induce all the benefits of competition where the cupola is concerned, and will stimulate those in charge of existing plant to make the very most of it.

Trading with Russia.

It is now some months ago since we dealt with this subject, and the publication in the Bulletin of the B.E.A. of a strong article from the pen of its director confirms the views we then expressed. The position in Russia is that its Government under its five-year plan intends to invest £5,400 millions in its domestic industries. The period necessary for the redemption of such a debt would be inordinately protracted, and thus £150 to £200 millions, which was dangled before the British Trade Delegation, sinks into insignificance by comparison, so the inference to be drawn is the extreme difficulty—or, perhaps, unlikelihood—of meeting the obligations of the latter in view of the former commitments.

Business *is* being done with Russia, and the liabilities incurred *are* being met, but they are only of relatively small dimensions. Moreover, for firms which have the necessary financial resources or can obtain them, there is not the slightest reason why they should not accept orders. What Mr. Bremner objects to, and an objection which we share, is the large-scale financing of Russian enterprises. There is a better and safer outlet for British capital in financing the rationalisation of the iron, steel and foundry industries. It was thought to be disturbing that America (which, by the way, does not diplomatically recognise Russia) was doing a very important business with the Soviet Government, but, to quote Mr. Bremner, "To the extent that America's manufactures were absorbed by Russia, the balance between world manufacturing capacity and effective world demand would be redressed to our advantage. Certain desirable markets would be able to absorb more of our manufactures and our situation be appreciably relieved. For the same reasons we might also contemplate philosophically an increase in Germany's exports were it not for the danger that the mysterious workings of the great financial machine in the City of London might result in our financing Germany's new adventures in Russia and indirectly providing the purchasing power to buy German goods."

Finally, the crucial point to our mind is that the unnatural development of Russian industries requires to be met by essentially orthodox methods of British enterprise, in order that we do not become inextricably entangled with what one might term financial wild-cat schemes.

XUM

Testing the Quality of Grey-Iron Test-Pieces.

INTERNATIONAL MEETING QUERIES VALUE OF SMALL TEST-PIECES.

The French official exchange Paper, prepared by MM. Le Thomas and Bois, entitled "Methods of Testing Cast Iron,"* and a memoir written by Mr. J. G. Pearce bearing the caption "The Influence of Size of Section on the Strength of Grey Cast Iron,"† formed the background for an expression of views on the relative value of the various methods used and proposed for evaluating the mechanical strength of grey-iron casting by foundrymen of all nationalities assembled for the recent International Conference. The British viewpoint was voiced by Mr. John Shaw, who said the Convention was indebted to MM. Le Thomas and Bois for a clear statement of their views concerning tests for cast iron. This discussion could but clear the air. He said at once that the limitations of the separately cast bar were recognised, but to say "That in no case will these bars give reliable information as to the casting be made from it" was but the exaggeration of a biased mind. So far as British experience went, while they recognised its limits, they had received more information regarding physical properties of a casting by testing a suitably-sized bar cast on the casting than by any other method, except testing the whole casting. Any test cut from the casting, at best, but represents that portion of the casting. The number that could be taken were limited, and often the places most liable to segregation, etc., such as the thick places in the ports of an engine, could not be tried.

Controlled Conditions Yield Constant Shear-Tensile Ratio.

There was also no doubt that under the very closely controlled conditions such as were specified by Le Thomas and Audo in their excellent Papers on foundry control, the shear tests would give fairly concordant results or that these results might have a fairly constant ratio to the tensile results on the same material. But that ratio would only hold good for the specified metal under consideration. That was the crux of the whole matter. Engineers the world over used the tensile strength factor to compute the thickness of their scantlings. Inspecting engineers also depended on this and the transverse result to pass with confidence the material examined, so far as the strength of the metal put into the casting was concerned. Could the shear test result be converted into the tensile result by a single constant? Or if not, could the shear test result be used for designing machine requirements? The answer to both these questions was in the negative. It was claimed that tensile results for cast iron were never correct. This, however, he did not admit if done carefully in a proper machine. After testing eight different bars it was found that, on testing again the broken halves, no result of any half varied more than 0.5 tons from the original bar. Norbury, before starting a recent investigation, also tried out this matter. From each of the two mixtures he cast four bars. His results were as follows:—12.8 tons, 12.7 tons, 12.4 tons, 12.9 tons. The other material gave 18.9 tons, 18.2 tons, 18.7 tons, 18.3 tons. Surely these figures are near enough for practical requirements. Even if it were granted that the machine or structure of the bar did not return true tensile results, the test would always be below the true strength figure and would thus only give an additional factor of safety to the engineer. On the other hand, it was always found that where shear and tensile results of metal of varying composition were given, there was a premium accorded to poor material by the shear test. Take but one example from experience: MacKenzie sent him a 2-in. by 1-in. bar of acknowledged poor iron. The modulus of rupture figure was 14.4 tons, whilst the shear test gave 26.4 tons. Such results might enable foundrymen to get poor material accepted, but it would recoil on them and deal a blow at the industry in which they were all interested.

History of Frémont Test.

Examining the history of the Frémont shear test, Mr. Shaw said that this engineer was not satisfied with the test methods in vogue 28 years ago, and turned his attention to the shear test. After designing a small machine for this purpose he collected 140 bars of known tensile and impact values and compared these results with shear tests taken from small pieces cut from these bars. From these results he drew certain conclusions. It was known now that these conclusions were open to serious doubt; in the first place, it was known that even the improved and modified Frémont shear machine shown at the last Exhibition held in London was not perfect. Attention was drawn to this by both Elliott and Rother. The author admitted this on page 4 of the preprint of the Paper in his reply to Professor Pishek and also the fact that he did not use this type of machine himself. It was known that in the foundries of 25 years ago the tensile machine was of a very crude character and its results not dependable. There was no information given of the chemical composition of the bars, nor if all were cast and tested in one size, and certainly there was no knowledge of their structure, and it seemed to him that the whole of Frémont's work was so doubtful, owing to causes over which he had no control, that it would be better left out of any argument. Surely, after six years' intensive propaganda such as had been made, more recent and dependable information could be produced. Unfortunately, this was not so, or at least it had not been published. There was the excellent unbiassed Paper by Professor Siegle given in 1923, whose conclusions were much in line with our own. There were also the two American reports by Elliott and Rother. They both agreed that on the same bar on the same machine the shear results were fairly concordant, but, as Rother pointed out, both workers obtained a different ratio of shear to tensile. Rother's figure was 0.75, whilst Elliott's was 1.3. Neither of them noticed that shear ratio to tensile increased in both cases with the lower tensile results, but it was so. Bolton's Table also demonstrated the same feature. If the 1.2 bars only were abstracted, the low tensile results a ratio of 1.5, whilst the highest showed 1.26. Pishek also produced confirmatory evidence, but he personally had not a copy of his figures. Ronceray gave a Paper on the subject, but it contained no other data but Frémont's original figures. There were also two excellent foundry-control Papers by Audo and Le Thomas, in both of which the same type of material was used, namely, a low-phosphorus, low-sulphur iron, and each strove to obtain a full pearlitic matrix. Very complete control was exercised from the initial raw material to the machined casting. As already stated, under these conditions concordant results might be expected, but this was for one type of material only and was of little use in arriving at a conclusion as to the value of the shear test when applied to the large variety of work both in design and mixtures that were now in use, where tests were called for. After all, it was an international test and not a works routine test that was sought for. It must be remembered also that both in France and in this country there were large quantities of useful iron carrying 1 per cent. phosphorus. That, to his mind, summed up the available information outside Britain, but there was no doubt that more work on a scale dealing with varied compositions had been done here than elsewhere, and these results were open for anyone to check in their own works.

Table A.—*Tests arranged in Order of Transverse Strengths.*

Transverse. Tons mod.	Deflection in in.	Shear. Tons.	Shear Trnvs. Tons.	Difference. Tons.	T.C.	C.C.	Si.	Mn.	S.	P.
14.4	—	26.4	1.83	+12.0	3.1	—	2.0	0.39	0.37	0:85
16.74	0.260	14.7	0.88	− 3.0	3.04	—	3.19	0.63	0.057	1.32
16.87	0.307	22.8	1.35	+ 5.9	3.25	1.12	1.56	0.27	0.128	1.17
17.75	0.346	23.7	1.34	+ 5.9	3.25	1.12	1.56	0.27	0.128	1.17
17.71	0.274	15.2	0.85	− 2.5	3.04	—	3.19	0.63	0.057	1.32
18.16	0.287	17.4	0.95	− 0.76	3.01	—	2.93	0.61	0.059	1.14
18.35	0.290	17.8	0.97	− 0.55	3.01	—	2.93	0.61	0.059	1.14
18.69	0.361	22.7	1.21	+ 4.01	3.25	1.12	1.56	0.27	0.128	1.17
18.78	—	26.1	1.38	+ 7.32	2.65	1.07	2.15	0.32	0.168	1.27
19.72	—	18.9	0.96	− 0.82	3.38	0.58	1.47	0.79	0.106	0.64
19.32	—	19.95	1.00	+ 0.63	3.44	0.49	2.03	0.72	0.089	0.86
20.0	—	13.5	0.67	− 6.5	3.50	—	2.00	0.57	0.08	0.57
21.1	—	12.4	0.59	− 8.7	3.30	0.60	1.75	0.65	0.08	0.39
21.17	—	13.67	0.64	− 7.48	—	0.28	—	—	—	1.00
21.68	—	14.31	0.66	− 7.37	—	0.36	—	—	—	0.90
23.45	—	20.0	0.85	− 3.45	3.51	0.61	1.61	0.72	0.10	0.74
25.2	—	18.2	0.72	− 7.0	3.22	—	1.54	0.61	0.07	0.36
25.6	—	18.4	0.72	− 7.2	3.16	—	1.50	0.56	0.06	0.56
26.5	—	12.9	0.49	−13.6	3.41	0.77	1.75	0.51	0.08	0.55
27.3	—	18.0	0.66	− 9.3	3.35	0.60	1.68	0.65	0.117	0.56
27.13	—	17.9	0.66	− 9.23	3.36	0.56	1.91	1.20	0.103	0.58
29.2	—	18.4	0.59	−10.8	3.17	0.87	0.68	0.67	0.156	0.166
32.8	—	20.47	0.62	−12.33	—	0.70	—	—	—	0.50
34.68	—	23.13	0.67	−11.55	—	0.95	—	—	—	0.50
35.4	—	18.7	0.53	−16.7	2.03	0.72	1.39	0.87	0.04	0.157
40.5	—	20.7	0.51	−19.8	2.03	0.72	1.39	0.87	0.04	0.157

British Opinion Crystallised.

Briefly, the findings, as the result of the work done on shear testing in this country, were:—

(1) The machine would need to be standardised if similar readings, even from the same sample, are to be obtained; also the least wear affects the results.

(2) That trepanning out a sample is useless unless that sample is either ground or machined to dead-size. Jolley has shown that with every reduction per $\frac{1}{1000}$ in. the result per square inch and ratio alters.

(3) That the 0.22-in. dia. bar is too small to give true results and is sensitive to graphite-size much more than 0.5 in. dia. Pearce found an increase of over 4 tons between 0.22 in. and 0.5 in. dia., three of each being tested from the

* See F.T.J., July 11, 18 and 25, 1929.
† See F.T.J., August 8, 1929, pp. 102-106.

same bar and position. A glance at Jolley's results also confirmed this. As the finer-structure metal is tested this difference ceases.

(4) If test bosses were drilled, as suggested by Le Thomas, it was found it depended again on the structure. Elliott stated one test taken from the centre of the boss gave 14.2 tons, whilst near the edge it showed 17.2 tons. Hyde obtained from the middle of the end section of a 2-in. by 1-in. bar, 15.4 tons, whilst tests from either side gave 18.6 and 19.5 tons respectively. A second bar from the same boss showed the same result. If the sample were taken from the casting itself it was found that by taking shears $\frac{1}{8}$ in. each time that the results were as follows:—15.3 tons; 14.6 tons; 13.8 tons. Reversing the same sample so as to start again with an outside edge, but taking cuts $\frac{1}{8}$ in. each time, the results dropped to the following:—15.3 tons; 13.5 tons; and 12.9 tons. Le Thomas mentioned the danger of separately tested bars being faked. With bosses cast on as he suggested, this was a much more real danger; a chill plate on the end or a few flat-headed nails flush with the mould would alter the boss structure entirely, and the fraud would be very difficult to discover.

TABLE B.—*Effect of Cupola Practice and Steel Additions on Physical Properties.*

Tns. T.sq.in.	Tns. sq.-in. 0.5 shear.	T.C.	Si.	T.C.+Si.	T.C.+$\frac{Si}{0.3}$	$\frac{\text{Shear}}{\text{Tensile}}$	C.C.	Mn.	S.	P.
9.8	16.8	3.44	1.56	5.00	3.91	1.71	0.59	0.68	0.11	0.64
10.0	16.2	3.46	1.60	5.06	3.94	1.62	0.56	0.65	0.114	0.48
10.9	18.2	3.41	1.93	5.34	3.99	1.67	0.51	0.76	0.103	0.54
13.4	20.0	3.43	1.49	4.92	3.88	1.49	0.63	0.71	0.113	0.68
13.5	19.9	3.44	2.03	5.47	4.05	1.47	0.49	0.72	0.089	0.86
14.9	20.4	3.43	1.98	5.41	4.02	1.37	0.53	0.74	0.110	0.61
17.6	24.5	3.35	1.49	4.84	3.80	1.39	0.60	0.76	0.12	0.51
18.1	27.0	3.36	1.47	4.83	3.80	1.49	0.56	1.20	0.103	0.58
18.8	18.6	3.43	1.91	5.06	4.00	1.00	0.58	0.72	0.116	0.76

(5) The dominating factors were that the shear-test result had no constant ratio to either tensile or transverse with varying composition. That in every case by this test a premium is placed on poor material, whether it be soft or brittle. In the case of Jolley's results, which extended over twelve months and covered at least 150 tests, the metal was always run into castings, and the test-bar used throughout was 14 in. by 1 in. by 1 in., the tensile and shear being taken from the broken transverse, yet the shear ratio to tensile varied from 1.37 to 1.84. Pearce's figures were from 1.07 ratio to 1.92; Hyde's figures on two mixtures only were 1.2 ratio to 1.42. Personally derived figures on turbine mixture were 0.99 ratio to 1.91 on hard but machinable iron; Cameron's figures on six mixtures were 1.04 ratio to 1.17. In every case the higher ratio went with the low tensile result. In conclusion Mr. Shaw assured the Continental visitors that the British had no other object than to serve our common trade. It did not matter from what source a better test procedure could be produced; if fully approved it would receive their whole support.

In justification of his conclusions, Mr. Shaw submitted Tables A to C.

The PRESIDENT remarked that the discussion revolved round whether a certain section of the foundry industry approved of the shear test or whether they did not. He hoped subsequent speakers would be as brief as possible. There was no necessity to stress the fact that different results were obtainable from different thicknesses of sections; such a condition of things was common to all and every test applied to cast iron. What it was desired to bring out in the discussion was whether the shear test as submitted by our French colleagues was a reliable and practical test for use in the examination of castings.

The Function of Testing Defined.

MR. J. T. MACKENZIE (American Foundrymen's Association) said that, speaking for himself, it seemed to him that the British and the French had arrived at some unanimity of opinion on this matter, although in different directions, but there seemed as many different opinions on this matter in America as it was possible to have. The principal exponent of the shear test in the United States was Mr. Bolton, who found it very useful for surveying castings, as he called it, but personally he did not think the fact that the shear test did not show a rectangular function of the tensile meant that it was not a function of the tensile. He was certain that in the case mentioned by Mr. Shaw there was a pipe in the centre, and the tensile test on such a bar would necessarily be low. He would never have used that example, because he was certain there was a pipe. In one case mentioned by Mr. Shaw he had a transverse test of 24 tons and 20 tons shear, with 2 per cent. carbon and 1.4 per cent. silicon, and if that bar were taken from the centre of the casting he did not see how one could expect to get a good shear test. In another case mentioned by Mr. Shaw the transverse was only 14 tons and the shear was 26 tons, the analysis being carbon 3.1, silicon 2.0 and phosphorus 0.85 per cent., and in that case 14 tons transverse appeared to be a very poor result indeed.

MR. SHAW said these results were obtained on a sample supplied by Mr. MacKenzie.

MR. MACKENZIE said his idea was that the test-bar was the evaluation of the metal in the ladle, and all the engineers could do was to take the service records of particular metals and try to assure themselves that new castings were the same quality as the one that had given good service. The endeavour was now being made to find that out in a little better way than formerly, but the fact that a shear or a tensile or a transverse test showed the properties of a casting did not mean that any one of them was good enough to set down as a complete engineering specification. At the same time, it was felt in America that all the tests now in existence were too valuable to be disposed of by adverse criticism.

TABLE C.—*Tests arranged in Order of Tensile Strengths.*

Tensile. Tons.	Shear. Tons.	$\frac{\text{Shear}}{\text{Tensile}}$ Tons.	Difference. Tons.	T.C.	C.C.	Si.	Mn.	S.	P.
9.8	18.7	1.9	+ 8.9	—	—	—	—	—	—
9.82	17.0	1.72	+ 7.18	3.44	0.59	1.56	0.68	0.11	0.64
10.0	16.25	1.62	+ 6.25	3.46	0.56	1.60	0.65	0.114	0.48
10.5	22.8	2.2	+12.7	3.25	1.12	1.56	0.27	0.128	1.17
10.8	14.9	1.35	+ 4.0	3.01	—	2.93	0.61	0.059	1.14
11.0	26.1	2.3	+15.1	2.65	1.07	2.15	0.32	0.168	1.27
—	26.4	—	—	3.1	—	2.0	0.39	0.37	0.85
11.7	23.7	2.0	+12.0	3.25	1.12	1.56	0.27	0.128	1.17
11.7	20.7	1.77	+ 9.0	2.03	0.72	1.39	0.87	0.04	0.157
11.7	13.69	1.17	+ 1.99	—	0.28	—	—	—	1.00
12.2	14.31	1.17	+ 2.11	—	0.36	—	—	—	0.90
13.2	20.0	1.52	+ 6.8	3.51	0.61	1.61	0.72	0.10	0.74
13.6	18.2	1.34	+ 4.6	3.01	—	2.93	0.61	0.059	1.14
15.5	21.6	1.4	+ 6.1	3.23	0.58	1.14	0.72	0.124	0.60
15.7	19.2	1.22	+ 3.5	3.20	0.88	0.86	0.67	0.17	0.17
16.0	18.2	1.14	+ 2.2	3.22	—	1.54	0.61	0.07	0.36
16.4	18.4	1.12	+ 2.0	3.16	—	1.50	0.56	0.06	0.56
16.4	24.3	1.42	+ 7.9	3.38	0.58	1.63	1.25	0.113	0.59
17.0	12.9	0.76	− 4.1	3.41	0.77	1.75	0.51	0.08	0.55
17.3	18.4	1.06	+ 1.1	3.17	0.87	0.68	0.67	0.156	0.166
18.3	21.9	1.20	+ 3.6	3.15	1.44	0.63	0.50	0.12	0.36
19.76	20.47	1.04	+ 0.71	—	0.70	—	—	—	0.50
20.56	23.13	1.125	+ 2.47	—	0.95	—	—	—	0.50
20.4	26.6	1.3	+ 6.2	—	—	—	—	—	—
21.3	28.0	1.3	+ 6.5	—	—	—	—	—	—
16.7	18.9	0.96 to 1.2	—	3.0	—	1.5	0.65	0.10	0.20
—	17.8	0.90 to 1.0	—	2.97	—	1.61	0.40	0.07	0.26

Official Belgian Attitude.

The following communication from the Scientific Committee of the Liége Section of the Association Technique de Fonderie de Belgique was then read:—

This interim report acknowledges that tests made on separately cast test-pieces do not give an absolute guarantee of the value of a casting.

Blowholes, slag inclusions, porosity, shrinkage cavities and internal stresses are amongst the many factors which react adversely upon the value of the casting, and which a test from a test-piece, even if of similar thickness as that of the average section of the casting, cannot reveal with certainty.

The Committee cannot reject the declarations of reputable foundrymen and painstaking engineers, setting forth the whole value of the information obtained during the last 15 or 20 years, based on the one side on tests made on separately cast test-pieces, nor, on the other hand, can they disregard the corresponding results obtained from daily practice established over very long periods.

The time necessary for the collection of such information is, in some degree, a measure of the fully justified fears of engineers with regard to any change in the type of test to be utilised.

The problem posed has three possible objects:—(1) To establish the value of a casting; (2) to establish the value of a type or mixture of cast iron; and (3) to establish the value of a new method of testing.

To Establish the Value of a Casting.

From the foregoing the Committee believe that the value of a casting (apart from such faults in the casting as have been mentioned above) may be judged from the properties of the iron, as ascertained by tests on separate test-pieces.

The Committee fully recognise the ingenuity of the shear test as applied to test-bars obtained by trepanning, and consider it as an interesting method worthy of further study and of being carried to the point of efficiency. The opinions of its members, however, differ on this subject. The test-bar obtained by trepanning is very irregular, and on that account gives only approximate results.

The principle of utilising transverse or shear tests is excellent under the condition of being applied to machine-finished specimens. The test-bars obtained by trepanning can only indicate local conditions existing in a small part of the material, the thermal history of which

may be as different from that of the whole casting as in the case of a separately cast test-bar.

The Committee has not rejected this method of testing. A series of experiments are to be made shortly, so as to permit of the giving of an opinion based upon figures.

To Establish the Value of a Type of Iron.

Our Committee have thought it useful to study the two British and American suggestions, both accepting the idea of a transverse test on a large-sized bar, and differing only as to application.

The British method provides three diameters of test-piece according to the average thickness of the castings; the American (and also the German) method, prescribes only one size of test-piece.

In order to be able to judge of these two methods, six foundries in the Liége district, represented on the Committee by their technicians, undertook to cast a series of test-pieces, in different qualities of iron, according to the three British dimensions. The results are summarised in the diagram annexed (Fig. A).

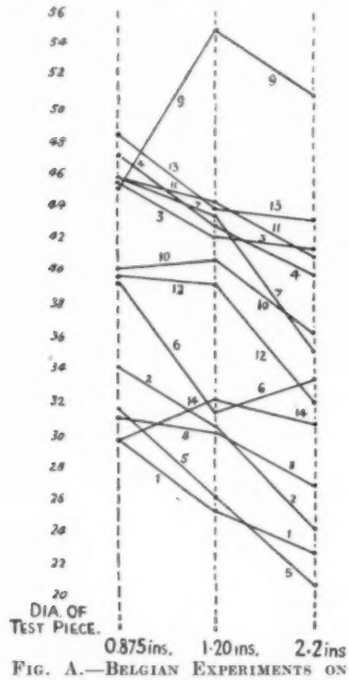


Fig. A.—Belgian Experiments on the British Test-Bar Scheme.

What are the purposes to be served by the ideal test-piece? Is it to determine the properties of different types of iron, cast in moulds for similar test-pieces, whilst actually these irons will have entirely different thermal histories?

Or is it to determine the maximum tensile that can be given by the iron—a question which supposes an inquiry into the most favourable thermal conditions?

The first direction leads us to the single test-piece (the American solution). The second to types of test-pieces of different dimensions, or to the British solution.

Conclusions.

In the majority of cases, where irons of inferior or medium quality are employed, the variation of results according to the size of the test-pieces is regular. From the results given with one test-piece one can anticipate within reason the results given by test-pieces of another size.

For certain special irons the variation follows another law. The medium-sized test-piece gives higher results than the two others.

It must be admitted that, according to the thermal history of the test-piece, the strength reaches a maximum, all other things being equal, for a definite diameter of test-bar. For the majority of their tests the Committee find it on the falling branch of the curve of the diagram; for other cases, the maximum corresponds to a diameter of about 30 mm. These observations conforming to theory, have led us to conclude in favour of the British specification, since a test on a single dimension, applied to all cases, will not permit one to draw conclusions as to the quality of the metal when cast in a greater or lesser thickness. It appears to us useful, if not necessary, to determine the quality of the metal when cast at a greater or less thickness. It appears to the Committee decidedly useful, if not essential, to determine the quality of the metal under conditions approximating to those met with in the actual castings.

To Establish a New Method of Testing.

With reference to a new standard test to be taken as a basis of comparison, the very great variety of results obtained with the same type of iron, according to the differences of its thermal history, induces the Committee to foresee the necessity of taking, as a basis of comparison, a measure corresponding to a single point of the curve of possible strengths of the iron, viz., that of maximum tensile strength, a consideration which brings us back again to the British thesis.

Fundamental Differences in French and British Views.

Mr. J. G. Pearce (British Cast Iron Research Association) said that the divergence between the British and French points of view on the test-bar question was so fundamental that it was really very difficult to discuss the present Paper without either apparent discourtesy or the use of methods of controversy that were not in the best interests of technical progress. He felt that both countries were aiming at the same goal but were approaching it by two entirely different ways, and mutual criticism might serve a very useful purpose in preventing the limitations of either country's methods being overlooked. He thought, however, that the authors of the present Paper damaged their case by lectures on the "force of habit and routine" and on the errors of the foundryman. The names of Frémont and Portevin were well known and esteemed in Great Britain, but the fact that they have "absolutely condemned" the tensile test did not justify us in abandoning the tensile test unless our experience supported their conclusions. This, however, was not the case. It was unfortunate, too, that the authors should so frequently brush aside the objections and difficulties raised by other experimenters by the remark that "the authors are not of this opinion" or "have not been able to observe anything of the kind."

The Paper of his own so much criticised by the authors did not find any place in their bibliography, but was reported in The Foundry Trade Journal in full on March 22 and 29, 1928, and he was flattered to think that it should have been treated so fully, for only a cogent statement of the objections to the shear test could have merited so much attention. So far as criticisms of the transverse and tensile tests and of the cast-off bar were concerned, the considerations he had put forward were not personal views but were the views which had guided the Grey Iron Committee of the British Engineering Standards Association in issuing the general specification 321-1928. This specification embodied both transverse and tensile tests, and the authors' criticisms were therefore criticisms of a British national specification, in the preparation of which every responsible body concerned had been consulted.

Development of the B.E.S.A. Specifications.

For many years the quality of particular cast irons for pipes, automobile, aeroplane and oil-engine parts had been governed by B.E.S.A. specifications. The preparation of a general specification issued in 1928 was the logical extension of this work, and the movement for a general specification was initiated by Mr. John Shaw before 1920. The general specification was being very widely adopted, and the testing provisions, which were the part which concerned us most at the present moment, would doubtless very soon be adopted for all British national specifications for cast iron. We were not seeking to impose the tensile and the transverse test on any other country, and we were prepared to discuss their disadvantages very frankly with a view to improvement. We were prepared to examine any new tests but we could not adopt them—and thereby undo all the work that had gone before—without overwhelming evidence of their advantages. That evidence was not forthcoming, either in the case of the shear test or in the particular form of the single shear test on a small bar advocated by Frémont. It would be interesting to know whether this test was used throughout France; whether it was specified by consulting engineers, or whether it found a place in the national specifications of France, Spain, Italy, Belgium or Czechoslovakia. Surely tests proposed for international use should first of all find general acceptance in a national specification.

Shear-Test Rarely Specified.

The authors were very critical about the drop or impact test, but since this test found no place in British national specifications we should never seriously suggest it for an international specification. Equally, however, we should not interfere with those who desired to use it for special purposes, for research work, and so on. The shear test was not new in this country. It was familiar to testing engineers and there was no demand for the single shear and only a very weak demand for the double-shear test on any material. The disadvantages of the tensile test given in his (Mr. Pearce's) Sheffield Paper applied in some cases (such as the necessity for accurate machining) even more to the shear test, and he therefore took exception to the authors quoting his comments after their own statement of the disadvantages of the tensile test, which could, with proper care, be corrected. The authors also quoted some of his test figures and concluded that there was little difference in shear value between 0.22-in. and 0.5-in. bars, quite overlooking the specific statement given in the Sheffield Paper that the piece of iron taken was specially chosen to try out the test and was very uniform throughout the section. There was ample evidence that in ordinary irons the 0.22-in. bar gave a shear value markedly lower than the 0.5-in. bar. The work of Mr. W. Jolley showed this clearly. In view of statements made and diagrams published in recent Papers, it was particularly interesting at this stage to learn that "it is illusory to look for any relation between shear strength and tensile strength." Other speakers would deal with the difficulties of the shear test and trepanning, and he could safely leave to Belgian, German and Czechoslovakian members to deal with criticisms of work done in their respective countries. He also took exception to the wholesale condemnation of the use of the rupture modulus. Doubtless, if this could be discouraged, the use of a single test-bar would be brought nearer to realisation, and on the single Frémont transverse machined bar the breaking load was enough, but when various sizes of test-bar were used, an inherent feature of the British proposals, the rupture modulus was the only rational way of comparing the strength of one size with that of another.

There appeared to be a slight error, possibly in translation, with regard to the section modulus K. This is described as the modulus of rupture and as not being calculable. K, of course, is the section modulus and is susceptible of mathematical calculation for any given section.

(To be continued.)

British Facilities for Foundry Training.—No. VIII.

THE METALLURGICAL DEPARTMENT OF SHEFFIELD UNIVERSITY.

By P. A. Fox-Allen (Associate Editor of the "Foundry Trade Journal.")

Of our educational centres it is perhaps fitting that Sheffield should have been the first to recognise the necessity of a higher standard of technical education for the foundry apprentice. The report of the Advisory Education Committee for the Sheffield Foundry Trades has already been published in our columns. As, however, the suggestions of that Committee would, if they could be adopted in their entirety, very fully meet every requirement for the combined scientific and practical instruction of the foundry apprentice, it may not be out of place if we again give an excerpt of the report, which provided for:—

The establishment of a special foundry course at the University, carrying a Foundry Technical Certificate for the apprentices or students who successfully complete the following course:

From 14 to 16 years of age.—English, Arithmetic, Machine Drawing and special Chemistry at the District Council Evening Schools.

From 16 to 18 years of age.—Mathematics, Machine Drawing and the Chemistry of Metallurgy at the Central Evening Schools.

From 18 to 21 years of age.—Completion of their Technical training at the Department of Applied Science of the University, including Physics and Metallurgy.

The Advisory Committee make the following recommendations to all Sheffield foundries:—

In order that satisfactory Technical Education be established for boys in the Sheffield Foundry Trade, the employing firms, where apprentices are not bound by indenture, should agree to make definite arrangements for the training of the boys in their foundry.

That whether the boys are indentured or not, encouragement should be given them, by increase of wages or otherwise, to attend regularly at evening classes, and to make progress in studies bearing on their occupation.

That where the apprentices are bound by indenture, a form similar to that already in operation in certain Sheffield firms be adopted, together with the addition of the following clause.

"Apprentices shall during the first two years of their apprenticeship attend, on two evenings a week while the schools are open, evening classes organised or conducted by the local education authority.

"All such attendances to be duly certified, and the apprentice shall further, if so required during the third and fourth year of the apprenticeship, continue attendance at such evening classes on not less than two evenings a week, or shall carry out and comply with such alternative arrangements as may be agreed upon, from time to time.

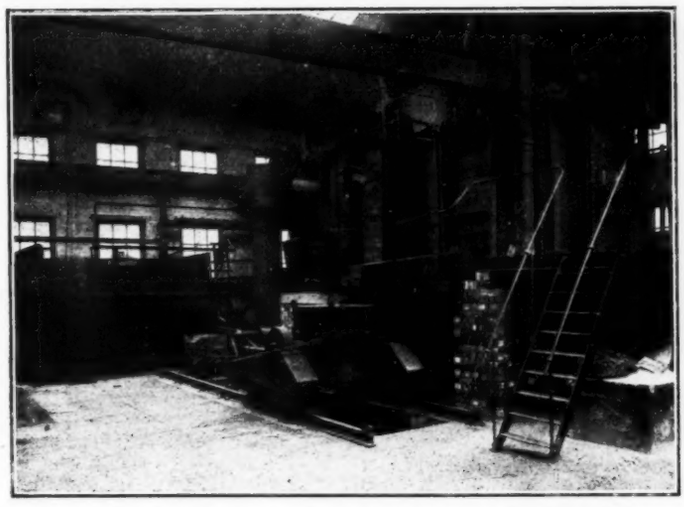
"Such alternative arrangements, if made, shall provide for the adequate tuition of the apprentice."

The scheme is receiving the assistance of many of the prominent manufacturers. Sheffield, however, is of course a steel-producing centre, and there are relatively few iron foundries of any pretensions in the immediate vicinity.

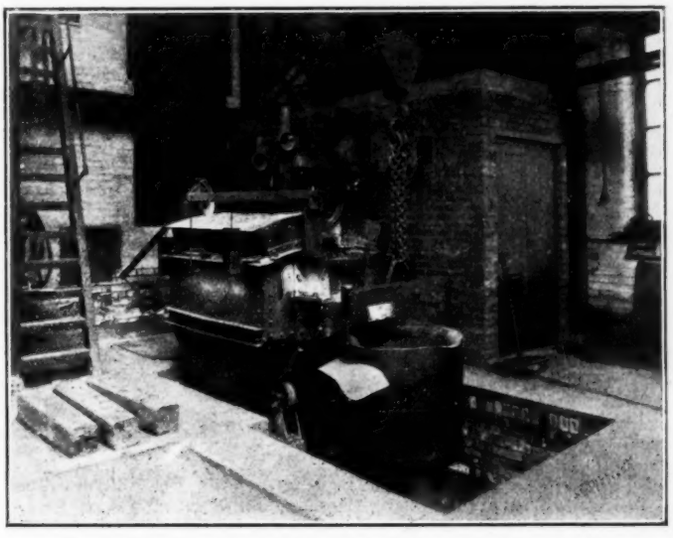
Messrs. Davy Bros., Limited, whose apprentices to the foundry are indentured, are giving the scheme very practical support, and at the same time affording every facility and encouragement for the boys to take advantage of the opportunities available.

It must be confessed that the results up to date have been somewhat disappointing so far as the boys are concerned, though the lectures are very well attended by adults, that such attendance will be mutually beneficial to the men and the industry in which they are engaged is beyond question, that however does not take us materially nearer to our goal—the higher education of the apprentice, who will be the man upon whom the future of our industry must depend.

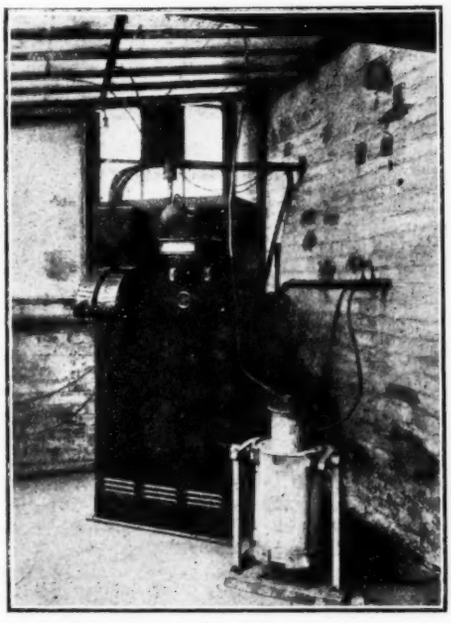
The course of lectures for the present year are, as will be seen from the synopsis, of a very comprehensive character:—



Two-ton Siemens Steel Furnace and Gas Producer.



Ten-cwt. Greaves-Etchells Electric Furnace.



Ajax High-Frequency Furnace.

Iron, steel, and brass; the essential properties of moulding sands and facings; the principles of green sand, dry sand and loam moulding; mechanical aids in moulding, plate and machine moulding, permanent moulds; characteristic features requisite in moulds for cast iron, brass, and steel; cast iron in the foundry, including malleable cast iron and the so-called semi-steels; brasses, bronzes and the light alloys in the foundry; liquid shrinkage and solid contraction in castings; physical properties of castings; foundry problems.

Department of Metallurgy.

The Metallurgical Department of the University of Sheffield had its birth in 1884 as a part of the Sheffield Technical School. When the charter of Sheffield University was granted in 1905 the Department became part of the Faculty of Applied Science. Separate degrees in metallurgy were established in 1907, and in 1917 the Faculty of Applied Science was divided, metallurgy and engineering becoming separate faculties.

From the outset, scientific teaching was supplemented by practical work on a sufficiently large scale to indicate to the student the nature of manufacturing operations.

The laboratories are equipped for all analytical and pyrometric work, for mechanical and magnetic testing, and for the preparation and examination of microscopical specimens.

Microscopical metallography owed its origin to the late Dr. H. C. Sorby, a Sheffield citizen, and under the guidance of Emeritus Professor J. O. Arnold a laboratory was installed for the conduct of this method of investigation. The present

equipment, which is contained in two laboratories, includes motor-driven polishing machines, and a number of microscopes by Ross and Watson.

Two small laboratories are provided for the determination of the critical points of steel. One of these has a potentiometer, astronomical clock and chronograph for plotting inverse-rate curves. The course in the magnetic properties of steels is taken in the Edgar Allen laboratory, which is specially arranged for research in this field. The laboratories for the study of refractory materials provide facilities for chemical and microscopical analysis, for tests of refractories in gas-fired and electrically-heated furnaces, and for mechanical testing at high temperatures in an Endell machine, whilst one room is devoted to investigations on moulding sands for the Cast Iron Research Association.

Owing to the increase of post-graduate students engaged in metallurgical research it has been necessary to provide a new laboratory and appliances for more advanced work. The equipment of this laboratory, provided mainly by the generosity of Sir Robert Hadfield and Viscount Bearsted, includes a high-frequency induction furnace of the Ajax-Northrup type, in which quantities of pure iron may be melted in a few minutes without contamination by air or fuel gas. When required the operation may be conducted *in vacuo*, the crucible being enclosed in a silica vacuum vessel, connected with a motor-driven oil-pump and a mercury-vapour pump. The laboratory is provided with large photomicrographic outfits by Reichert and Zeiss, and a microscope for examination of surface detail. A high-temperature thermostat and a dilatometer are used for experiments on the physical properties of metals and a special apparatus, devised in the Department, makes use of thermionic valves to determine the stress at which metals first begin to deform beyond the elastic range.

The change of volume of iron and steel during melting and freezing is under investigation, a special furnace and balance being used.

There is a complete equipment for the study of X-ray spectra of metals, including a gas tube supplied with current from a special transformer, a Highvac rotary oil-pump, mercury vacuum pumps, and cameras for taking photographs by any of the alternative methods in use for research. A Hilger quartz spectrograph is used for the quantitative determination of small traces of foreign metals in alloys. There is also a high-frequency furnace for producing very high temperatures in exhausted vessels supplied with current from a large thermionic valve; an apparatus for the measurement of volume changes in molten metals; a continuous-flow calorimeter for the determination of heats of solution and reaction, and an equipment for the measurement of electrical resistance at high temperatures. A new laboratory with large rolling mill and draw bench has been equipped for research on the cold-working of metals.

On a site immediately adjoining the laboratories is a small steelworks which is equipped with a 2½-ton acid Siemens open-hearth furnace, the gas for which is supplied by a Duff water-bottom producer; this producer also supplies the gas for a series of regenerative crucible holes. Ingots up to 36 cwts. each have been cast for the Ingots Committee of the Iron and Steel Institute. A 10 cwt. Greaves-Etchells tilting electric furnace, taking current from the 11,000-volt mains through a transformer, is used like the Siemens furnace for making experimental melts of steel. Experimental melts are also made in the high-frequency furnace. A 4-ton overhead electric crane is used for moving the ladles and ingot moulds. A separate building contains coke-fired crucible holes of the usual Sheffield type.

During the operations of the various furnaces, the students take an active part in the work; obviously this is not intended as a substitute for a works experience, but as the conditions can be varied in a manner which would be wholly impossible in a large furnace, the student may learn to appreciate the various factors in the successful melting and refining of steel. A 36-in. Whiting cupola and moulding floor are provided for work on cast iron.

A further feature of the experimental works is the provision of a series of furnaces for the hardening and heat-treatment of steels used for tools and cutlery. These include coke, gas, coal and electric furnaces of various types, which may be controlled by means of pyrometers, or, in one instance, by a magnetic indicator. Lead, salt and oil baths are provided. Mechanical testing is carried out in the Jonas testing laboratory, which is shared by the Engineering and Metallurgical Faculties. The equipment includes testing machines for tension and compression by Buckton, Armstrong-Whitworth, Riehle Denison and Avery. Hardness tests are taken on Standard Brinell machines, "baby" Brinell using small balls, Rockwell, Vickers, and Herbert pendulum machine. For the investigations on the fatigue of metals two Haigh electro-magnet machines are available, and one each of the Wöhler and torsional types. These are provided with optical devices for short period tests.

The laboratories for non-ferrous metallurgy are arranged for analysis, and a melting shop with coke- and gas-fired furnaces is attached. The equipment includes a sand-blasting machine.

A New British Chemical Standard Bronze "A."

The third of a series of non-ferrous standard analysed samples is now ready for issue. The analysis is as follows:—

	Per cent.
Copper	85.5
Tin	9.96
Zinc	1.86
Lead	1.83
Phosphorus	0.25
Antimony	0.24
Iron	0.07
Nickel	0.04
Arsenic	0.06

This standard has been prepared in order to meet the need of a gunmetal and a phosphor bronze, the two being combined in one standard. It will enable chemists to check their methods of analysis and to settle disputes between buyers and sellers. The composition does not correspond to any particular specification, but the sample contains all the elements usually met with in the ordinary gunmetals and bronzes. The analyses have been made by ten chemists experienced in testing this class of alloy: reference chemists, Government Departments, manufacturers, and users are represented.

The standard is available to anyone at a price based on ultimately covering the cost of preparing and issuing it. The three usual sizes—50-grm., 100-grm., and 500-grm. bottles—are provided, and a certificate, giving the names of the analysts collaborating, together with their analysis and notes on the methods used, is furnished with each sample. For further particulars apply to British Chemical Standard Headquarters, 3, Wilson Street, Middlesbrough.

Activity in the steel plant at Sydney, N.S., it is reported, continues to be on an excellent scale, the number of men employed—2,650—being greater than at any time since 1918, when the plant was busy with war orders. All the mills are working, and they have worked more steadily during the past six months than at any time within the last five years. Recent orders placed with the Dominion Iron & Steel Company include one from the Government of Newfoundland for 11,000 tons of steel rails, for the railway between Port aux Basques and St. John's.

Youth in the Foundry.

By R. F. Coates.

As still a "Youth in the Foundry" the author proposes to outline, from his own experience, the advantage of technical study by the foundry apprentice. The trade to-day offers everything in the way of success to the ambitious lad on leaving school. The foundry undoubtedly has the great appeal of science, and is consequently full of interest to the intelligent youth.

A visit to most foundries does not give the appearance of a congenial place in which to work. The writer, looking back to his first visit as a boy, and since learning a little of the technical side of the trade, the foundry appears as a good book in an old cover. The appearance is uninteresting, but beneath the surface lies knowledge, education, and finally success for its students.

Although the lad on entering the foundry to-day does not receive so much personal instruction as those of the last generation, he is compensated by the fact that this develops his initiative, by having to use his own discretion. Whilst there are many problems that must be taught, there are also many which by observation and forethought can be solved by a keen lad. During the first year a course of core-making is usually undertaken, and every advantage should be taken of the instruction given, as that which is well learned early remains. It is worth remembering, too, that in the production of clean and sound castings it is equally important that both cores and moulds are well made.

Engineering is an industry that demands attention to detail; and this is as important in the foundry as other departments.

If the learner is given an intricate pattern and core-boxes, to carry the core-making and moulding operations throughout proves both interesting and helpful. Before starting any job the pattern and core-boxes should be examined. This gives an idea as to their assembling and to make allowances for the bringing off of air and gases at the most convenient points. Runners and feeders, too, must be decided upon before the pattern is put into the sand.

It is most encouraging for a lad to work in this way, especially when he sees a clean and sound casting in the fettling shop; for it gives him a feeling that he has done almost everything in the production of the particular casting. Rejected castings come to all, and these must be turned to good purpose by finding the defects and causes and so preventing their recurrence.

The youth should now have reached the stage when technical school attendance is essential. These are held in the majority of industrial centres, although within the author's experience many are discontinued through poor attendance; again emphasising the scope there is for the studious. By attending these classes a greater interest is created in the daily work, for if a lesson is on the different constituents of iron, and how they affect the properties, the student will examine scrap and so forth with more interest and knowledge. A course of lectures on metallurgy is necessary, for it is just as important that the foundryman must know the rudiments of this interesting science, as the metallurgist should, of foundry work.

The men who will be able to fill the higher posts in the future are those that have acquired a combined practical and theoretical training. The youth possessing these qualifications is assured of success, for it is agreed that there is a shortage of skilled men, and an equal shortage of men who can fulfil important managerial posts.

In conclusion, the author hopes that he has encouraged those already in the foundry, and that he may have influenced those seeking themselves, or for others, a trade with a great future for a keen lad.

The Heat-Treatment of Grey Cast Iron.*

By Edward E. Marbaker, Ph.D.[1]

Introduction.

The heat-treatment of the iron-carbon alloys containing comparatively low contents of carbon, and known as steel, has received a great deal of attention, and it is now considered a very important process in the manufacture of steel objects whether they be cast or forged. A great body of scientific information has been contributed to the literature, and heat-treatment has become an important department of the metallurgy of steel.

Grey cast iron has been defined as a steel of eutectoid composition (0.90 per cent. C.), the structure of which is differentiated from that of a true steel by the presence of an excess of carbon which occurs as graphite flakes. The latter break up the continuity of the structure to such an extent that the strength is very much less than that of steel. Fracture generally takes place below the elastic limit so that in such a structure little or no elongation can take place. The hardness is due to the constituent known as pearlite, which consists of alternating layers of iron carbide (cementite) and pure iron (ferrite) and which is the only component present at 690 deg. C.[2] Because this constituent is formed in the solid state it is called an eutectoid in contradistinction to a true eutectic such as ledeburite (austenite and cementite), which is formed as the liquid metal becomes solid at the freezing point (1,130 deg. C.).

While considerable information exists on the heat-treating of grey cast iron, it has been looked upon as a dangerous procedure, and until very recently the process was employed in very few foundries. One of the reasons for the slow progress in this field of investigation is the difficulty in obtaining satisfactory experimental results due to the fact that, compared with steel, cast iron is a very complex alloy. In the case of steel, the carbon always occurs in the combined form, and the constituents such as silicon, manganese, sulphur and phosphorus are generally so low in amount as to be more properly considered as impurities. In the case of cast iron it is necessary to have present appreciable quantities of silicon and manganese in order to obtain the desired structure, and for many grades the phosphorus must be present in amounts sufficient to provide the desired fluidity. Sulphur occurs in cast iron as an impurity, and usually strenous efforts are made to remove it. However, it occurs in greater amounts than in steel because the melting processes of the cupola do not have the same effect as those of the open-hearth furnace in which the molten metal is not in actual contact with the sulphur-bearing fuel.

In discussing the metallurgy of cast iron, it is usually considered as an alloy of iron with more than 2 per cent. carbon. The other elements are more or less disregarded, although they are known to have far-reaching effects, because the construction of an equilibrium diagram of two components such as iron and carbon is much less difficult than that of a three-component system such as iron, carbon and silicon, and when a fourth component is added, the task becomes so difficult as to be almost impossible.

However, notwithstanding the difficulty of the subject, a great deal of work has been done, and it has been established that the properties of grey-iron castings can be profoundly affected by the use of a suitable heat-treatment. The object of this Paper is to bring together the more recently communicated information with the hope that the interest of foundrymen, metallurgists and engineers may be aroused, and that further experimental and practical work will be carried on which may result in the improvement of the properties of cast iron. Many Papers have appeared recently on the effect of casting temperatures, methods of moulding and rates of cooling, all of which are instrumental in producing grey cast iron of more uniform structure, and physical properties superior to those of ordinary grey cast iron. These variables come into play while the molten metal is cooling, while in heat-treating, the variables which must be controlled are related entirely to the metal in the solid state. The latter may be considered in a way as the reverse of the former, and it is certain that the physical laws which control the various steps in one process are equally effective in the other.

The Theory of the Heat-Treatment of Grey Cast Iron.

The study of the heat-treatment of cast iron and its effect on the properties of the metal must go back to the question of the constitution of the iron-carbon alloys. If the cooling curve of pure iron were being determined, it would be found that after the iron has solidified the temperature continues to fall regularly until 900 deg. C. is reached. At this point the cooling ceases for a time because heat is being evolved in the iron itself as an internal molecular rearrangement takes place. Above this point the iron is non-magnetic. When the rearrangement has been completed (the change from gamma to beta iron), the cooling proceeds to 760 deg. C., at which point there is a second "arrest." This is accompanying the change of beta iron to alpha iron. The latter cannot hold carbon in solution. In pure iron there is a third arrest at 700 deg. C., but it is very slight. When the cooling curves of the iron-carbon alloys are determined it is found that the first two arrests are not present, but that the third has become very prominent, and this increases in magnitude as the percentage of carbon increases up to a maximum of 0.90 per cent., and this is known as the critical temperature, and from the heat-treating standpoint it is very important because the properties of cast iron change materially at and above this temperature as will be shown later. The change in structure which takes place at this temperature during cooling is from austenite to pearlite. The theory of the formation of pearlitic cast iron depends upon the very slow cooling of the casting through this temperature in order that plenty of time may be available for as complete a transformation as possible. If the casting is cooled very slowly below this point, the pearlite will break up into ferrite (alpha iron) and graphite, with the result that it will be very soft.

The process may be reversed and by reheating the ordinary casting from room temperature the pearlite may be changed into austenite at a definite temperature which is close to that temperature on the cooling curve at which the austenite changes into pearlite. In this case, however, the transformation is accompanied by an absorption of heat, and the rise in temperature is retarded. In the case of an ordinary cast iron, Piwowarsky[3] found the Ac_1 to be 810-825 deg. C. and the Ar_1 to be 780-725 deg. C. Ordinarily Ar_1 is called the critical point because, as stated previously, in metallurgical investigations, it is the cooling curve which is usually determined. The more recent investigations have been based on a knowledge of the two temperatures, and it has been found that in heat-treating it is important to cool the metal very slowly between Ac_1 and Ar_1.

Obviously, in working out schedules for heat-treating it is necessary to disregard the excess carbon, because the properties of the iron which it is desired to change are inherent in the constituents which are common to both steel and cast iron, and consequently the structural changes which accompany heating and cooling in the range from 0.0 to 0.90 per cent. carbon are those which have to be taken into account. The elements present in cast iron, other than the carbon, such as silicon and manganese, exercise a profound influnce on the physical changes which take place in heating and cooling and on the properties of the metal, and therefore only the fundamental ideas developed in the study of the thermal properties of true steel can be used. The practice must be worked out for cast iron in accordance with its analysis, and a heat-treatment which brings about the desired results in one type of cast iron will not necessarily be effective in the case of another type. This is perhaps the reason why the heat-treating of cast iron has not received the attention it deserves from the practical foundryman.

Influence of Time Element

The time element in heat-treating is as important as the temperature, because the material is in the solid state and the motion and speed of the molecules during the transformation is highly restricted and necessarily slow. Ordinarily no attempt is made to secure complete transformation because the long time necessary increases the cost greatly, but it has been found that the changes in structure proceed far enough during a reasonable time to materially influence the properties of the metal. When it is desired to maintain in the cold a particular structure which exists at a higher temperature, the casting is cooled very rapidly or "quenched" by plunging it into cold water or some other cooling medium. The equilibrium conditions existing at the higher temperature cannot change as would be the case in slow cooling.

Heat-Treatment for Strain Removal.

In actual heat-treating operations in general there are two conditions which may be brought about. In the first of these it is desired only to remove strains which have been produced by irregular cooling in the mould, and which perhaps do not show up until after the casting has been machined. In such cases there may be considerable warping. In order to prevent this, the casting may be partly machined, and then heated to a relatively low temperature for a sufficient time for the molecules of the iron to rearrange themselves and to relieve the strains which lead to the warping. In older foundry practice it has been customary to allow castings to stand in storage for a period of weeks or months to "season." In this case the strained condition tends to relieve itself at ordinary temperatures. The time involved is so long that this method affects production adversely, and it is less costly to heat-treat the casting and accomplish the same result in a relatively short time. This practice is sometimes called "normalising." After the casting has been so treated, it may be completely machined without further danger of warping or growth.

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In the second case, heat-treatment is applied for the purpose of softening the casting to make it more easily machinable by either changing the entire structure to a softer form or by the removal of hard spots and segregated areas. It is necessary in this case to heat the casting above the critical temperature and holding for some time dependent upon the extent of the change desired and cooling slowly through the critical range and perhaps finally quenching from a relatively low temperature.

It may be of interest to indicate the structural changes through which the iron-carbon alloy passes as it cools slowly. S. J. Felton[4] gives the following table in which the relation between the various constituents and the hardness is shown:—

	Shore.	Brinell.
Cementite	120	800
Martensite	100	600
Austenite	90	550
Troostite	70	400
Sorbite	45	275
Pearlite	30	200
Ferrite	17	100

Cementite is very hard and cannot be machined. It is the structure which is found on the surface of chilled castings and is produced by rapid cooling. It is of great importance in the malleable-castings industry, for there the castings consist originally of white iron, which is essentially cementite. This is brought about by using low silicon contents in the charge to prevent the precipitation of carbon as graphite and by relatively rapid cooling. In order to render the castings useful, they are subjected to a heat-treatment or annealing which is called "malleablising." The castings are heated to a temperature well above the critical point (between 704 and 760 deg. C. usually), and held for two to three days. The cooling must be very slow, especially to 677 deg. C. which is below the critical temperature. The process generally requires five to six days altogether. At the annealing temperature the metal consists of cementite and austenite, and as the cooling proceeds the cementite breaks down into ferrite and a peculiar finely divided form of graphite which is called "temper carbon." Because of the presence of the graphite in this form, the continuity of the structure is not broken up as it is in grey cast iron by the curved plates of graphite, and consequently malleable cast iron is much stronger than grey cast iron, and has a higher resistance to impact.

The process just described is time-consuming, and it results in a product possessing properties which render it useful for certain purposes. The object of this Paper is to show that shorter processes can be used, not for the purpose of completely changing the character of the cast iron, but to maintain the original structure in a general way and at the same time improve certain of the properties. For instance, in the low-temperature treatment already referred to, the strains are removed, and in general the strength and hardness of the iron are only slightly diminished. In the treatment at higher temperatures the iron becomes softer, as in the malleable process, but at the expense of a part of the strength. However, heat-treating schedules have been worked out in which the desired reduction in hardness has been attained without diminishing to any great extent the original strength of the material.

In working out a schedule for heat-treatment it is well to determine the critical point of the particular cast iron in question by the ordinary methods of thermal analysis, that is, by plotting the cooling curve or by using one of the newer dilatometric methods. According to Potter,[5] the critical temperature of grey cast iron and semi-steel can be calculated with a fair degree of accuracy from the chemical analysis according to the following formula:—

$$\text{C. T.} = 730 \text{ deg.} + (28 \text{ deg.} \times \% \text{ Si}) - (25 \text{ deg.} \times \% \text{Mn}).$$

This is an empirical formula which is based on the fact that silicon raises the critical point and manganese lowers it. The 730 deg. C. is taken as the critical point of the pure iron-carbon alloys. It may be of interest to show how this formula is worked out. Given an iron containing 2.00 per cent. silicon and 0.60 manganese, the critical temperature is determined as follows:—

	$28 \times 2.00 = 56$
Subtracting	$25 \times 0.60 = 15$
	41
Adding	730
Critical temperature	= 771 deg. C.

According to the previous reasoning then, it would be necessary to heat this iron above 771 deg. C. in order to bring about the desired transformations.

Results of Reported Investigations.

In order that it may be shown how the foregoing theory has been reduced to practice, and that in the heat-treatment of ordinary grey cast iron there is a possibility of developing a method of improving the properties of castings which can be carried out at little additional expense, it is proposed to set forth in the remaining part of this Paper the results of the various investigations as they have been communicated in the literature.

Low-Temperature Annealing for the Removal of Strains in Castings.

Practically no scientifically conducted investigations on the heat-treatment of cast iron *per se* were reported in the literature prior to 1915, although there had been many important contributions on the fundamental subject of the constitution of the iron-carbon alloys and that of the growth of cast iron, in which thermal studies were necessary. In the Papers on the former subject, especially those of Hatfield, Longmuir, Goerens and others, the mechanism of the formation of the carbon steels was explained. In the Papers on the latter subject it was pointed out that the structure of cast iron is profoundly affected by heat-treatment. While these investigations were not concerned with the practical results of heat-treatment, they form the theoretical basis of subsequent work.

Table I shows the preheating schedules which have been shown to be applicable in the elimination of casting strains:—

Table I.

Author.	Annealing temperature. Deg. C.	Time. Hours.	Cooling.
Anonymous ..	593	8	slow (24 hrs.)
Sherwin	593	24	slow
	205	24	slow
Hurst	575	72	slow
	575	150	slow
Wiltshire ..	371	7	slow
Harper and Mac-Pherran ..	621	1	slow
Rolfe	593	1	slow
Bolton	371–538		slow
Donaldson ..	450–550		slow
Grotts	315		slow
Capp	500–550	4–10	slow
Bolton	371–427		slow

Summing up the results of these investigations it is found that some discrepancy exists. This is doubtless due to differences in analysis of the irons and the casting conditions. It is well known that the original structure has a profound influence on the success of heat-treating and obviously the time element is diminished in cases where the original structure is uniform. From these and other investigations (which will be cited later) it appears that the desired results may be obtained by heating at a high temperature for a short time or at a low temperature for a long time. This is borne out by the fact that in the "seasoning" of castings the strains are relieved at ordinary temperatures if a sufficient time is allowed. It would appear that some of the investigators unduly prolonged the time of their tests, and since the temperatures were well below the critical range (732 deg. C.) the properties of the castings were not materially changed. This is indicated by Sherwin's results which were practically the same whether the bars were heated at 593 deg. C. or 205 deg. C. for 24 hours. Rolfe's results show that at 593 deg. C. such a long heat was unnecessary, for he accomplished in one hour all that for which Sherwin required 24 hours.

High-Temperature Annealing to Influence Changes in Structure.

The second purpose for which cast iron may be heat-treated is to make the structure more uniform and to reduce the hardness to render it more easily machinable by reducing the combined carbon content. It is also possible to change the structure to improve the strength and the resistance to impact. In this case it is found that the theory explained in this Paper must be followed and the castings heated to a temperature above the critical range, generally about 732 deg. C. for the commercial irons. This, it will be remembered, is the temperature at which steel containing 0.90 per cent. carbon shows an all-pearlitic structure which is considered to be best for general purposes. By heating above the critical temperature for a time depending upon the size of the casting, in order to change the structure to austenitic, and then cooling slowly through the critical range, and subsequently cooling rapidly, it is possible to "trap," as Cammen[6] calls it, the pearlitic structure, and thus obtain a cast iron of superior quality.

As in the case of the heat-treatment for the purpose of relieving casting strains, no scientific studies of this problem *per se* were reported before 1915. In that year, G. S. Evans[7] made a very careful study on a series of ten commercial irons varying in structure from light grey (almost all cementitic) to dark grey (pearlitic with excess graphite) and of Brinell hardness varying from 318 to 185. The silicon contents were high, varying from 2.70 to 3.81 per cent. The rate of transformation of the combined carbon into graphite was found to increase with temperature from 704 to 982 deg. C. However, this is so rapid at 898 deg. C. that in ordinary practice where the combined carbon does not run over 0.50 per cent. and with no appreciable chilling, it is simply necessary to heat to 898 deg. C. and cool immediately either in the furnace or in the open air to obtain the softening effect without materially affecting the strength. No change in composition or hardness was noted when the annealing took place at 677 deg. C., or below. The change was slow at 704 deg. C., indicating that the critical range was between 677 and 704 deg. C., the low range being due to the high silicon content. This is confirmed in malleable practice but not by the results of Potter's later investigations. Potter,[8] however, worked with cast iron of lower silicon content, as is the custom in malleable practice. For instance, one of Evans' samples having the following composition:—T.C. 3.28, G.C. 2.70, C.C. 0.58, Si 2.98, Mn 0.32, S 0.086 and P 1.20 per cent. as cast showed a Brinell hardness of 237. After heating at 760 deg. C. for five minutes and cooling in the furnace to about 427 deg. C. during a three-hour period, and then in air, this sample showed a hardness of 141, and the fracture was pearly. The combined carbon was completely changed to graphite.

Piwowarsky,[9] in 1922, carried out annealing experiments at various temperatures and for different periods of time on a pearlitic cast iron having the following compositions:—T.C. 3.18, G.C. 2.49, C.C. 0.69, Si 2.95, Mn 0.63, S 0.068 and P 0.102 per cent. The Ac_1 of this iron was 810 to 825 deg. C. and the Ar_1 was 750 to 725 deg. C. At temperatures below Ar_1 the rate of decomposi-

tion of the pearlite was not high enough for practical purposes. Between Ar_1 and Ac_1 the rate is satisfactory when the silicon is sufficiently high. Rapid annealing is obtained by quickly heating to a temperature a little above Ac_1, in this case 836 deg. C., and cooling through Ar_1 (732 deg. C.) at a rate less than 1 deg. per minute. Although Piwowarsky obtained the result of greatly softening the iron, he states that the heat-treatment of iron has only a limited significance. This is doubtless due to the fact that he is greatly interested in the production of cast iron of the highest grade directly from the cupola, and which will require no further treatment.

At about the same time, Schüz,[10] who is also interested in the improvement of cast iron, carried out an investigation of heat-treating in relation to cast iron. In his Paper he explains very clearly the changes in structure which result during heat-treatment. It is claimed that satisfactory annealing results from heating at 700 to 800 deg. C. from three to ten hours depending upon the size of the casting. He also shows that for an iron of the following composition:—T.C. 3.56, G.C. 3.06, C.C. 0.56, Si 2.26, Mn 0.56, S 0.112 and P 0.38 per cent., of Brinell hardness 160 to 164, in a 24-hour annealing period the carbide decomposition begins at 500 deg. C. and is complete at 600 deg. C.; for a six-hour period the reaction begins at 550 deg. C. and is complete at 650 deg. C.; and for a three-hour anneal the decomposition begins at 575 deg. C. and is complete at 650 deg. C. "These results are surprising," says Schüz, "since the critical temperatures are much lower than is generally accepted." He explains this by the fact that relatively little of the original carbon is combined and the graphite tends to gather in the temper carbon produced by annealing. This investigation further substantiates the theory that annealing at a high temperature for a short time has an effect equivalent to annealing at low temperatures for a long time.

J. F. Harper and R. S. MacPherran[11] state that when annealing to improve the machinability, the castings should be heated to 788 to 843 deg. C. and cooled slowly. The decrease in hardness is accompanied by a loss in strength.

A process for heat-treating white or grey cast iron was patented by A. K. Schaap (U.S. Patent 1,514,070, November 4, 1924) for which several claims of an unusual nature are made. Such cast iron is so soft that it can be tied into knots, and besides its strength is not greatly below that of the same iron which has not been heat-treated. In his Paper describing this process, Bradley Stoughton[12] cites the objects of heat-treating cast iron as follows:—(1) Improvement of machinability, including the elimination of hard spots, the attainment of softness without toughness under the tool; (2) softness and anti-friction qualities for bearing service as in piston rings; (3) pliability and malleability so that the material may be distorted cold without fracture, may withstand shocks and blows without breaking, and may be hammered into a new shape either hot or cold; (4) freedom from crystalline brittleness in order that it may resist blows which do not strain the iron beyond its elastic limit, and (5) freedom from brittleness due to internal stresses produced during cooling or otherwise.

The process is carried out by heating the casting to a temperature slightly above the critical point (871 deg. C.), while protecting it in a muffle surrounded by a gas flame and open at the top. Wrought-iron muffles proved to be best. As soon as the iron reaches the proper temperature the muffle and its contents are removed from the furnace and allowed to cool in the open air, the casting being protected from drafts. About 15 minutes are required to cool to a black heat, after which it may be cooled in the open air. The entire operation, starting with cold iron, requires 45 minutes. The time must be increased when treating heavy castings.

The following result is typical:—

	Untreated. Per cent.	Treated. Per cent.
Total carbon	3.39	3.30
Graphitic carbon	2.73	3.19
Combined carbon	0.66	0.11
Silicon	2.36	2.50
Manganese	0.37	0.29
Sulphur	0.064	0.086
Phosphorus	0.736	0.746
Brinell hardness	240	140
Tensile strength, tons/sq. in.	9.798	8.96
Transverse strength, tons/sq. in.	1.294	1.232

F. Grotts[13] reported the results of his investigation of the heat-treating of cast iron in 1925 with the idea of showing that the physical properties of the material can be radically modified by suitable heat-treatment. His primary object was to show that castings containing hard spots and therefore difficultly machinable need not be scrapped, for by heat-treating the structure may be rendered uniform throughout. Working with a cast iron of the following composition:—T.C. 3.24, Si 2.46, Mn 0.96, S 0.150, P 0.514, which had a transverse strength of 1.772 tons and a Brinell hardness of 131, he found that by heating to 649 deg. C. the hardness was reduced to 92 and the transverse to 1.62 tons. By heating to 760 deg. C. (above the critical) the hardness was further reduced to 90 and the strength increased to 1.692 tons. Thus he is justified in concluding that heat-treatment can be used to soften the iron without greatly weakening it. For certain classes of work he advises a heat-treatment at 954 deg. C. for a short time, then machining, and finally heat-treating again, followed by quenching and drawing to the desired hardness. This latter procedure is not unlike that of Knowlton,[14] which is used primarily for hardening castings. In Knowlton's process, the casting is case-hardened by carburisation in the usual way, and is then reheated to 927 deg. C. for 3 hours, cooled to 836 deg. C. slowly, and then water quenched. It is claimed that some samples so treated were considerably stiffer than malleable castings and possessed a toughness comparable with that of case-hardened low-carbon steel.

O. W. Potter[15] has made a very complete investigation of the heat-treating of cast iron and strongly advocates its use as a means of improving the properties of castings. In his conclusions he states that the best combination of properties was obtained by heating at 871 deg. C. for three hours, and cooling to black in 15 minutes and then to room temperature in air. This is much like the Schaap process, the difference being that Potter held the metal at the annealing temperature for three hours while Schaap proceeds to cool immediately after that temperature is reached. Potter obtained, as did Schaap a uniformly soft casting with only a slight reduction in strength. As other investigators had found, Potter noted that holding the metal at a high temperature for long periods of time resulted in extreme softness, due to the complete decomposition of the iron carbide, and great reduction in strength. He also advocates the heat-treatment, followed by machining, a subsequent heating and quenching to harden the metal and thus obviate the dimensional changes due to growth. In a more recent Paper, based on further experimental work, Potter[16] restates his conclusions, but in his heat-treating schedule, the time for holding at the annealing temperature is reduced to two hours.

J. W. Bolton[17] summed the matter up very recently in a general way by stating (and in this he follows Piwowarsky) that castings should be heated at a temperature somewhat above the critical temperature and then cooled slowly, at least in the temperature range between Ac_1 and Ar_1. The time necessary is less the higher the temperature and the smaller the casting. Small castings can be completely annealed in a few minutes at 871 deg. C. The metal becomes softer, more malleable and weaker.

G. C. Priester and F. J. Curran[18] worked with a number of cast irons of usual composition at temperatures from 797 to 898 deg. C. for varying times. Their results corroborated those of the other workers in this field. They sum up their work by advising the heating of the casting at a temperature above the critical and cooling slowly.

A table in which the results of the preceding investigations are recapitulated follows:—

Author.	Annealing temperature. Deg. C.	Time. Hours.	Cooling.
Evans	760		3 hrs. to 427 deg. C.
	898	0	3 hrs. to 427 deg. C.
Piwowarsky	836	5 mins.	1 hr. through 732 deg. C.
Schüz	750–800	3–10 hrs.	slow
Harper and MacPherran	788–843		slow
Schaap	871	0	slow to black heat
Potter	871	2–3	slow
Bolton	871	depends on size	slow
Priester and Curran	797–898	0	slow
Knowlton	927	3	slow to 836 deg. C. and water quench

There is much closer agreement among the schedules cited in relation to the softening of cast iron to attain better machinability than was the case with those for the purpose of relieving strains. It will be noted that in general the theoretical considerations have been substantiated and that in general the properties of cast iron can be improved in certain respects by heat-treatment. The question arises as to whether iron castings of uniform structure and unstrained, even though the strength may be lower, are not superior from an engineering standpoint than ordinary untreated castings.

Conclusions.

The best results in normalising strained castings have been obtained by heating at temperatures considerably below the critical temperature for periods of time depending upon the size and section of the castings, the object being to insure the heating of the castings throughout at the annealing temperature, and then cooling slowly.

In order to soften the casting and make it more easily machinable, it must be heated at a temperature above the critical point, held for a sufficient time to ensure thorough heating, and then cooled slowly at least through the first 55 deg. C. Castings can be hardened again after machining, if desired, by reheating, quenching and drawing to the desired hardness.

Slag for Making Ferro-Manganese in Electric-Furnace Tests.—About 150,000 tons of metallic manganese is being supplied annually to the steel industry in the form of manganiferous iron ores from the Lake Superior district. The North Central Experiment Station of the U.S. Bureau of Mines, in co-operation with the University of Minnesota, has been developing modifications of blast-furnace and open-hearth practice so as to recover some portion of this large tonnage of metallic manganese in a form suitable for making ferro-manganese. Electric-furnace tests were recently made at the Pittsburgh station of the Bureau to determine the relative merits of the electric furnace as compared with the open-hearth for treating high-phosphorus spiegel so as to produce a high-manganese slag that can be used for making ferro-manganese. These tests indicate that the electric furnace has the advantage of shorter time, more positive control of phosphorus and iron in the slag, more uniform slag lower in silica, and cleaner separation of slag and metal.

Various Conference Papers Criticised.

The Critical Examination of Steel Castings.

By G. F. Gillott.

The President expressed regret that so little time was left for the discussion on this Paper, and he asked those who desired to discuss the Paper to communicate their comments in writing. He said that he sincerely hoped that this course would be followed, because the efforts of authors who prepared Papers were greatly appreciated and this subject in particular was of special importance.

Unfortunately, in the complete examination of steel castings one had generally to wait until the casting was scrapped. If some means could be devised which would enable a casting to be thoroughly examined before despatch, it would be an extremely useful thing. Such means may be within the scope of X-ray examination. He had visited the Research Department at Woolwich and had witnessed one or two demonstrations showing what could be done in that direction. He thought it well to say, however, that we must not be too hopeful, because it appeared to him that there is a long way to go before this test could be accepted for routine purposes in workshops or foundries. It would seem to require a body of men trained in foundry practice to get the best results from this method of examination. Where new designs of castings are concerned, it might be that good use could be made of the method of examination by X-rays. He understood that the greater part of the work done so far had been done on parts which were known to be defective or in which a defect was anticipated, and the location of the probable defect indicated beforehand. Whether X-ray examination would ever become practicable in the foundry for examining large and intricate castings generally he would not venture to say. Nevertheless, it was steadily advancing as a method of investigation, and some very good prints had been obtained.

Mr. H. O. Slater said the Paper was so important that he thought a little time ought to be given to the discussion of it. He asked the author whether he had had any hand in designing the brackets on the casting to which he had referred, or whether they were put on by the founder according to his own ideas of eliminating cracking. He was wondering whether there was any relation between the number and size of the brackets and the thickness of the metal, because he remembered the case of a steel casting upon which 30 brackets had been found sufficient to prevent cracking, where a far greater number of different dimensions and differently placed had been unsuccessful. Had the author found any difficulty in this connection in similar cases?

The Author said that in the case referred to, and in most cases, all the brackets were placed by the maker of the castings, who was given freedom to place brackets and similar additions where he thought they would prevent defects. He had no doubt Mr. Slater was quite right in suggesting that the cracks in this particular case were due to incorrect proportioning of the thickness of the brackets to the thickness of the casting. If that had been given attention the cracks would probably not have occurred.

Mr. Slater said his point was that the practical man might be able to prevent a casting from cracking by judicious use of brackets, easing, coremaking, etc.

The Author agreed, and said that was a condition which X-ray examination was intended to remove. In the case in point, the crack had produced another defect in a different position and, although this latter was not such a dangerous one, the casting would have been rejected because of it.

Mr. J. T. MacKenzie (A.F.A.) remarked that in the case of a high-pressure boiler in the United States, the specification called for X-ray examination of each individual casting.

Mr. H. A. Schwartz (A.F.A.) said that had been done in many cases in America and particularly with oil stills. For small castings it was a very satisfactory method.

The President agreed that for small castings X-ray examination was very useful, but the difficulties he had suggested were in regard to large castings. He was wondering whether the defects mentioned in the Paper had been found independently by those making the X-ray examination, or whether they had been prompted as to where to look for the defects in castings which had been rejected. In the case of a large and intricate casting, he assumed it would take a very long time to explore the whole of it by means of X-rays to ascertain if there were any internal faults before such a casting was put into service.

On the motion of the President, seconded by Mr. J. E. Fletcher, a cordial vote of thanks was passed to the authors of the Papers read at the Congress and to those who had taken part in the discussions. The President said it was lamentable that so short a time was available for the discussion of the many important Papers presented. The result had been that some of the Papers were not discussed to the extent they warranted. He earnestly asked that anybody who was in the position to do so should contribute his quota by written communication, so that the record of the Paper and the discussion thereon might be as complete as possible.

The Problem of Foundry Moulding Sands.

By H. Van Aarst.

Mr. J. G. A. Skerl (British Cast Iron Research Association) wrote that this short but interesting Paper raised the important issue of testing methods. The author of the Paper had taken test methods from various sources, methods which in the countries of their origin have not received the unqualified support of the committees dealing with the question of sand testing. Is it too much to ask that from this international gathering that some attempt be made to form some international committee to discuss this problem? The need for such a committee may not be apparent to many foundrymen at the present time, but in the near future the issue will have to be faced. For example, in the steel industry of this country the development of synthetic sand mixtures is coming to the fore, but until sand-testing methods are internationalised we will not be able to make the fullest use of the published results of American and German workers on these synthetic sands.

The Influence of Graphitisation of Cast Iron.

By Professor Diepschlag.

Dr. A. L. Norbury (British Cast Iron Research Association) wrote that he was greatly in sympathy with the author when he stressed the important effect that the size and number of the graphite flakes in the pig-iron used had on the size and number of the graphite flakes in the resulting casting. He had expressed somewhat similar views in a Paper last month to the Iron and Steel Institute.

By suitably varying the melting conditions (in crucible melts) it was possible to produce at will castings containing very coarse graphite flakes or, alternatively, castings containing the fine kind of graphite that the author called eutectic graphite, and to produce both types from a given pig-iron without any material alteration in chemical composition. He did not find, however, that refining the graphite increased the strength in all cases. For instance, in pearlitic castings, refinement of the graphite beyond a certain stage resulted in the production of ferrite in place of pearlite, and this lowered the strength more than the refining of the graphite increased it.

The Elimination of Sulphur from the Alloys of Iron.

By K. Gierdziejewski.

Mr. E. J. L. Howard wrote that he had read with considerable interest the above Paper. Three years ago he had occasion to attempt to reduce the sulphur content of the iron being used in the foundry, and thought that the most simple method to adopt would be the use of soda ash. It was found that ¾ lb. of soda ash to each 1 cwt. of metal placed in the bottom of the shank affected a reduction of 30 to 35 per cent. of the sulphur content. The higher the sulphur content, the greater appeared to be the percentage reduction, and with irons containing 0.06 per cent. sulphur only about 10 per cent. was reduced. After treatment the metal seemed to be much more fluid and appeared to run better, although considerable difficulty was encountered in getting rid of the slag, sodium silicate being very thin, but if lime or fine sand were thrown on to the surface of the metal it could be readily skimmed quite clean. The linings of the ladle were badly cut into by this slag, and had a very short life. He understood that there is a lining, suitable for ladles in which this treatment is carried out, now on the market. He would be interested to know if the author considered there was much advantage to be gained by de-sulphurising metal containing less than 0.06 per cent. sulphur, and if the metal so treated has a lower viscosity than the untreated.

Catalogues Received.

Economisers.—The modern catalogue tends to become more and more a compilation of valuable technical data. A high-class brochure, just issued by Eco Power, Limited, 15, Lincoln's Inn Fields, W.C.2 (a subsidiary of E. Green & Son, Limited, Wakefield), describing the Foster economiser, its construction and operation, is in this sense quite modern. A concise and instructive discussion on the economiser, its features and functions, both as a steaming and non-steaming apparatus, is followed by a description of the construction, which comprises machined cast-iron gilled rings shrunk on to a solid-drawn steel tube.

The calculation of fuel saving and the increase of boiler capacity by installing the economiser is briefly dealt with, and then follows an instructive section on induced draught. Dealing with the corrosion of tubes, the effect of velocity of flow is clearly illustrated by photographs relating to tests on corrosion by flowing water. The flow of fluids in smooth pipes is a further subject discussed, and then follow curves showing the weight of gases resulting from the complete combusion of coal and oil and the relation between water-temperature rise and gas-temperature drop in an economiser for different ratios of weight of gases to evaporation. Tables of properties of saturated and superheated steam are further included, and the whole is copiously illustrated by excellent views of power stations in which the Foster economiser is in use. The brochure is thus not only interesting but instructive.

Forgings—Messrs. Steel, Peech & Tozer (The United Steel Companies, Limited), The Ickles, Sheffield, have prepared an eight-page pamphlet, telling in concise language, accompanied by suitable illustrations, the story of their methods for producing steel forgings and the "service to buyer" to be associated with this production.

Practical Hints on Non-Ferrous Casting.

LANCASHIRE FOUNDRYMEN HOLD STRONG VIEWS.

An interesting discussion followed Mr. Hopwood's paper* on the above subject, the principal points from which are extracted below.

MR. J. S. G. PRIMROSE, in proposing a vote of thanks to the author, said this was an eminently practical Paper, embodying much information which would be of value in everyday practice to those who had to make good castings out of these somewhat trick alloys. Not infrequently, non-ferrous work, the production of castings in bronze or brass, was carried on in connection with an iron foundry, at odd times as circumstances required. It was much better to have a properly constituted foundry controlled by a properly-trained man who understood the work of his furnace, whether it was the ordinary pit fire or a modern type—the oil fire or, as some hoped for, the electrical furnace.

A New Type of Furnace.

One type of furnace shown by Mr. Hopwood might have surprised some of those present who were accustomed to using a pit fire with ordinary straight bars. It was quite common to find up to 50 per cent. of carbon monoxide in the waste gas, and that represented a great loss of the heating power in the furnace. Now Mr. Hopwood had shown a device for solving that trouble. It was to replace the straight bars by an inverted truncated cone with holes in it. There was no coke below the crucible. The coke could be placed round about and all the heating was done in the furnace. The extent of the improvement was that the carbon monoxide in the flue gases fell to less than 2 per cent., and this accomplished a saving not only in time but also of nearly 45 per cent. of the fuel used.

MR. E. FLOWER, in seconding the vote of thanks, asked Mr. Hopwood to explain the reference to burning castings.

The vote of thanks was passed unanimously.

Welding Small Defects.

MR. HOPWOOD said, that when preparing a Paper of this kind, it was not possible to think of everything germane to the matters dealt with, and he would therefore be glad if the members would aim for completion in the discussion.

In a brass casting but little was needed to cause the inclusion of a speck of dirt which would be thought sufficient reason for rejection. There was a strong inducement, therefore, to adopt burning as a method of remedying defects. In a small casting it was easily done.

But take the case of a large casting which had drawn at the riser. Five lbs. of metal was put on the draw and burned in, after which the casting was solid. But that raised the question whether burning altered the structure. In his opinion, it was bound to do so when there was so great a weight of hot metal associated with local heating of the section. Thus, although it was solid it was not necessarily sound.

The BRANCH-PRESIDENT remarked that Mr. Hopwood had brought out clearly one difference in practice between non-ferrous casting and a ferrous casting, that was, the question of proper melting and regulation of temperature.

Facings for Small Brass Castings.

MR. J. PELL pointed out that the Paper did not say what kind of facing was used in brass castings. Was blacking, peas' meal or analogous material used to produce a good skin on the casting. When making a brass casting in dry sand he thought the natural course would be to use wet blacking and dry it in a stove.

In his own practice he made castings, such as the ends of cylinders, which had not to withstand any test. They were cast green, usually the heavier ones were blacked with a coat of plumbago.

MR. HOPWOOD said he had overlooked the question of facings. For ordinary work generally, or for green work castings weighing from a few ounces up to a hundredweight were faced off with ordinary baker's flour. For cores he had seen whitening used—ordinary talc or French chalk mixed with water—but that rubbed off. The addition of a little salt to the talc and water mixture helped to overcome that trouble. Large moulds which are to resist the action of molten phosphor bronze are wet-blacked and skin dried.

Material for Pressure Castings.

MR. J. A. REYNOLDS asked whether Mr. Hopwood used briquetted swarf. His company's method was a re-melt and pour into ingots after passing through a magnetic separator. Had members experience of using the swarf direct without re-melting and ingotting, that was by briquetting the swarf and adding it direct to the mixing?

What was the most suitable alloy for pressure work, to withstand 100 lbs. air pressure under water without leaking? He had in mind a thin annular ring, with a flange say 1½ in. thick.

It would stand pressure satisfactorily if it was left unmachined, but machining disclosed minute porosity all round the ring, under the radius at the junction of the varying sections. There was the same trouble with green sand or with dry sand. The castings varied in size. The only trouble was the pressure; otherwise the castings were perfectly satisfactory. The metal used was phosphor-bronze, 88½:11½. Perhaps gun-metal would be more suitable.

MR. HOPWOOD: It depends on what the casting has to stand afterwards.

MR. REYNOLDS: It is an electrical accessory working on high voltages, the interval fittings being immersed in oily compound which must not leak away.

MR. HOPWOOD suggested 88.6.4.2 would be a more suitable alloy; it would be better than phosphor-bronze, which was a difficult alloy to cast. One ought to assure the correct casting temperature and suitable metal, and never vary from it.

Overcoming Common Defects.

MR. A. SUTCLIFFE asked whether the moulder who made the casting under discussion had tried it with a chill all round. Receiving a reply in the negative, he said he thought if it was chilled on the outside, getting a close grain, and the fillet made a little larger, there would be no further trouble.

Mr. Hopwood had not mentioned the life of a pot, nor suggested how the life of the pot could be lengthened. There was a way of doing that, but he would like to know what was Mr. Hopwood's practice.

The reference to burning reminded him of a visit he made to a brass foundry in Bolton for which he was making a quantity of cores. Looking round, he saw a 4-in. pipe, for which he had made a core about 7 ft. long. The core had lifted, and he asked what was going to be done about it. The reply was, "That will be all right. We are going to burn it." It was 7 ft. by 6 in. That would never be a good job. Think of the thickness on the bottom side of that pipe, and the price of brass. It would have been cheaper to make a fresh one. What temperature did Mr. Hopwood consider to be correct for casting aluminium?

Mr. Sutcliffe exhibited on the screen an illustration of a large brass step casting, weighing 4½ cwts., which, he thought, would interest Mr. Hopwood. He asked whether anyone would run such a casting with one runner. If one runner was used it would drop down the other side, and would scab the casting in consequence. It was bad practice not to run it on both sides, so that the metal would come up level when filling the mould.

For this mould he used sand of an ordinary mixing, associated with dry-sand work. He showed a sample. For the facing they rubbed the mould with plumbago and washed it over with a French-chalk wash. This sand should have a good ramming and be cast at a suitable temperature, which was required with this class of work to produce good castings. Pitting or burning-on was caused by poor ramming. Another trouble was sand burning off and running in front of the metal when being cast. This also happened when casting at wrong temperatures, particularly in making lead pipes. He preferred to use Mansfield sand rather than the common yellow sand for green-sand brass work.

Influence of Tramp Iron.

MR. HOPWOOD said he took the question about briquetting brass swarf to refer to 60:40. On a certain class of job that could be used. They used it in small amounts as it came off the lathe. If brass became mixed with iron to any appreciable amount, in the liquid state, it showed itself by the continuous appearance of flakes of iron oxide on the surface of the molten brass.

MR. PELL observed that a briquetting machine was used for brass swarf.

MR. HOPWOOD said with machine-shop borings the stuff had just been turned straight off the lathe, it dropped on the floor and was picked up by the shop labourer. If that was melted right away a pot of the borings would contain a certain proportion of dirt. In that, one had iron and the amount of it might be detrimental to the alloy. He had seen castings which contained hard spots owing to iron or steel that had not melted.

MR. PELL pointed out that this material could be briquetted after it had been through the magnet machine.

MR. J. CLIFFE suggested that 15 lbs. of borings be placed at the bottom of crucible, and then the copper and scrap. This was a help to quick melting and avoided the necessity for briquetting.

Life of Pots.

MR. HOPWOOD said a question had been asked about the life of a pot. There were several varieties of pot on the market, besides the ordinary plumbago pot. One kind of "super" pot was being used at the present time; but another sort they found did not pay for the extra cost entailed. The ordinary plumbago pot must be kept in a warm place. Their practice was, before using, to put it on a slow fire—a fire which had just been lighted with dry coke. To eliminate steam from the pot and coke constituted the most serious problem.

It might interest some people to know that using an ordinary salamander pot which had to deal with molten copper for electrical purposes, with an ordinary day of five melts and then shutting down the furnace, they got an average of 60 melts per pot; but with continuous running, with only about four shuts down, they could get about 120 melts per pot.

The casting temperature of aluminium varied according to the alloy. For the ordinary copper-aluminium alloy, or the copper-zinc-aluminium alloy, the casting temperature was always somewhere round about 700 deg. C. Working on that figure the foundryman would never go far wrong.

Facing Cores and Moulds.

MR. J. MASTERS said there were many swarf-briquetting machines on the market. Recently he was at a place where this process of briquetting the brass swarf had been thoroughly studied. After it had been melted for a period,

* See F.T.J., August 15, p. 112.

the material was analysed, and its approximate composition ascertained. The mixing was 62 per cent. copper, 35 per cent. zinc, 1 per cent. iron. Sufficient manganese was added to bring the manganese content to 0.4 per cent. and they cast direct. The blowing out of cores was referred to. In most places that practice had gone by and would never return. He had in mind a place where 66,000 cores were used in a week; not a single one was blown out, they dropped out.

When blacking the core or painting the mould, the latest practice was to use plumbago with a binding material. It gave no trouble and produced a perfect skin. There were several non-ferrous paints which were highly efficient and did the job quite well.

To his mind there had been a lot of needless controversy about melting aluminium. Several people had put in oil furnaces for that purpose and were getting exceedingly good results. He knew one firm which was casting 70 tons per week in nothing but aluminium, and doing it very efficiently. At another place upwards of 50 tons were cast weekly in ordinary gas-fired furnaces with cast-iron pots. Practically all the work was tested. It was an aluminium-copper alloy; as the metal was wanted it was filled in from batteries of pots up and down the works, taken to the casting station—so many ladles—and then poured direct. Oxidation never troubled them. Owing to the thickness of the pot and the heating apparatus the metal was very rarely overheated, and therefore was not as liable to oxidation as some people seemed to imagine.

He was rather surprised Mr. Hopwood had not mentioned pyrometer control of the alloys. In non-ferrous work such control was essential, especially where one was casting high-duty bronzes. Mr. Hopwood was quite right in regard to the use of wood charcoal for melting.

The modern non-ferrous foundry used oxide catchers to reduce the loss of the easily oxidised metals. Oil was sprayed on the moulds for aluminium castings and then the mould was put in a stove for a short period—from 20 mins. up to 40 mins. if it was a fairly big mould. They cast quite well and were clean and sound.

Coke-fired Furnaces being Superseded.

Mr. Hopwood said for casting aluminium the oil-fired and gas-fired furnaces were far in advance of the ordinary coke-fired furnace. One had more control over the atmosphere. With regard to coating the mould, some firms, when they wanted the skin dry, sprayed benzol or petrol and then fired. They had the skin dry immediately. He thought one could not improve upon the ordinary green sand, working with the sand rather on the dry side. That was his practice and he rarely had any trouble with castings up to 60 lbs. in weight, which in aluminium was a fairly big casting, there being a considerable surface.

Hints on the Care of Pots.

Mr. S. G. Smith, referring to melting pots, said the life of these varied considerably. All pots, whether made in clay or blacklead, absorbed moisture from the atmosphere. When a lad he was working in the brass shop with a moulder who, although an experienced man, put three pots in the pit fire successively, and in each case the bottom gave way. That was because those pots had not been annealed to a sufficiently high temperature before being put into service. In the first place, they should be kept in a warm place and before using a higher heat was needed. 100 deg. C. was suitable, followed by a gradually higher temperature before they were put in the fire. That was the method adopted afterwards, and there was no further trouble with them. Blacklead or plumbago pots were a very expensive item.

Regarding melting brass in a cupola. An experimental cupola was now being tried-out for melting non-ferrous alloys, but he did not think the results were yet published. At the time to which he had just referred, over 50 years ago, they melted several tons of brass in the cupola. The castings they were making were heavy bearing brasses. It was too much weight to tackle in the pit furnaces, so they resorted to the cupola, and it both melted well and ran well. But there was something the matter with all the castings. A very soft blast was used, but the melting losses must have been high, also absorption of gases and impurities by the metal would be high, which was probably the cause of complaint.

Non-Ferrous Scrap in the Jobbing Foundry.

By Neville Deane.

In the non-ferrous jobbing foundry it is often the case that the judicious, or otherwise, purchase of scrap metals means the difference between profit and loss. A few hints as to pitfalls in this matter, which are the result of hard experience, may be of some service. First in importance is probably brass scrap. There are various "official" grades, but every scrap merchant is a law unto himself as to how he applies them. What will be heavy cast scrap to one, is light cast scrap to another. *Caveat emptor*, or in plain English, let the buyer beware.

Generally speaking, genuine heavy cast brass is good for anything except specification work, but very often the scrap is in such large pieces that it has to be made red hot and broken before it can be put into the crucibles for melting. This is a laborious and time-wasting job, and should be avoided whenever possible. Light cast-brass is very useful for making similar light work, and is usually of such a size that it will go into the melting pots without much trouble. It is, of course, usually loaded with as much spelter and lead as it will possibly carry, and yet be brass. Therefore be careful not to use it for special work where a reputation may be at stake. With regard to new and old sheet cuttings and rolled brass, unless the melting plant is such that it can be handled easily, leave it alone. It is no joke to have to fill a crucible six or seven times with sheet cuttings in order to get one heat out, and any savings in cost soon vanish in the cost of time wasted. It is useful sometimes for mixing special alloys, and that is all.

Gun-Metal Scrap.

This is difficult material with which to deal. Good, old bearings, steam fittings and the like are excellent, but much of the newer scrap metal contains far too much spelter to be good for general work, and many modern bearings contain large amounts of lead which is satisfactory for bearings but unsuitable for other work. The best test in a simple way is to cut or file the surface. If a red colour appears it is most likely to be of normal quality, but the more yellow and brassy it looks the worse it is. Something can be learnt from the manner in which it files or cuts, *i.e.*, soft, hard, chippy, soggy, etc. Testing gun-metal scrap is quite an expert job.

One point necessitating care is that in old Ford cars there are certain gear wheels which were die cast in aluminium bronze, and which look like gun-metal, except that they are rather more golden in colour. One of these wheels will spoil two or three hundredweights of good metal, and it is often done. The resulting castings are extremely hard and brittle, and the fracture nearly white. Unless the reason is known, it is very difficult to find out the cause of it.

Spelter and Lead.

With regard to spelter, new sheet cuttings are good; old rain-water gutters are worse than bad. There is some cast spelter in the form of old statuettes, etc., which is obtainable, but only in small quantities. It is fairly good, but generally holds other metals. Never buy the hard zinc from the bottoms of galvanising furnaces. It is cheap and attractive to think one can remelt it and purify it somewhat. But it will not melt properly, as it holds several per cent. of iron and is useless for foundry work. The spelter distiller is the only one who can handle it with profit.

There is not much difficulty about lead scrap, the only point being that, if pure lead is needed, try to get large-sized tubes or sheet scrap, as small tubes are often "Compo." "Compo" is often better than the pure lead, however, where it is desired to harden the metal for patterns, etc. Tin is rarely obtainable as a scrap metal, syphon tops and similar goods being about the only common forms, and these are alloys.

Aluminium.

Aluminium scrap is rather a difficult problem. It is only of use for second-class work; even then it needs great care in selection. New sheet cuttings are good for alloying, but it takes a great amount of time and labour to keep on filling it into the melting pot. Old sheet metal goods are even worse to handle, and produce a great deal of dross. Cast scrap is so variable in composition that it requires some courage to use it direct. There are copper, zinc, copper-zinc, silicon and other alloys, and where one is so unfortunate as to mix several different alloys in one heat, the result is interesting, but is not encouraging.

As a result of practical experience, unless one knows the class of alloy the scrap belongs, it is best to leave it alone and buy ingots of definite compositions. This course may sacrifice some money in first cost, but will pay for itself in the long run.

Copper scrap is generally fairly good in quality if one excepts fire-box scrap and similar metal. Tubes, wire, sheet and rod are quite good for mixing purposes where a higher copper content is wanted in brass, gun-metal, etc., but most belong to the class of scrap which takes up a considerable amount of space in the crucible without any very great weight of melted metal being obtained. Other scrap metals are not of very general importance to jobbing foundries, and include nickel alloys, pewter, white metals of the lead, tin and antimony class.

Publication Received.

The Bradley Mixture Service. Published by Bradley & Foster, Limited, Ironmasters, Darlaston, Staffs.

This is one of the most interesting booklets which has passed through our hands for some time. If we interpret its message correctly, the object is to stress that with the purchase of the firm's pig-iron there is included a service to the client of an erudite and well-informed character. In the booklet, generalisation has naturally had to be resorted to, but the generalisations carry with them a maximum utilitarian value. The system has been to provide two charts and three tables. The first chart (Fig. 2) is an adaptation of Campbell's diagrams, wherein the element contents for T.C., Mn, and P of their own refined irons have been included for working out desired compositions in association with an ordinary pig and scrap charge. The second chart (Fig. 1) depicts two curves, one for general and the other for special purpose, derived from plotting the silicon content against average thickness of casting.

Table I gives the compositional limits of a series of Bradley's irons, and Table II, the average for each brand. Table III outlines compositional suggestions for castings falling into five classifications and is directly associated with Chart I. Altogether, a good deal of thought has been put into the booklet and, as an introduction to a service, it has more than achieved its purpose.

Iron and Steel Institute.

Papers to be Read at the Autumn Meeting in Newcastle.

In accordance with previous announcements, the Autumn Meeting of the Iron and Steel Institute will be held at Newcastle-upon-Tyne. The sessions will take place in the Festival Hall of the North-East Coast Exhibition on Tuesday, Wednesday and Thursday, September 10 to 12, commencing at 10.15 a.m. on Tuesday, and at 10 a.m. on Wednesday and Thursday. The secretaries' office will be open at Neville Hall, Newcastle-upon-Tyne, on Monday, September 9, from 3 to 6 p.m., for the distribution of programmes and badges. At the conclusion of the meeting visits have been arranged to works in the district. The following is a complete list of Papers which it is expected will be submitted to the meeting:—

"Notes on Wire for Mining Ropes," by A. T. Adam.

"The Solubility of Carbide in Ferrite," by H. A. Dickie.

"Electrical Conductivity of Magnesite and some other Refractory Materials in Relation to the Temperature and their other Properties," by E. Diepschlag and F. Wulfestieg.

"Notes on the Damping-Down and Re-Starting of Blast Furnaces," by C. S. Gill.

"The Hardening of Superhardened Steel by Magnetism. The Lattice Resonance Hypothesis," by E. G. Herbert.

"Crystallisation and Segregation Phenomena in 1.10 per cent. Carbon Steel Ingots of Smaller Sizes," by A. Hultgren.

"High Elastic Limit Structural Steels," by J. A. Jones.

"The Hardness of Vacuum-Annealed Crystals of Iron," by H. O'Neill.

"Iron in Antiquity," by T. A. Rickard.

"The Correlation of Fatigue and Overstress," by J. H. Smith, C. A. Connor and F. H. Armstrong.

"The Coalescence of Pearlite," by J. H. Whiteley.

"Iron-Silicon-Carbon Alloys. Constitutional Diagrams and Magnetic Properties," by T. D. Yensen.

Note.—Additional meetings will be held at Scunthorpe on September 17, and at Birmingham on September 26, 1929.

Papers for German Foundrymen's Congress.

At the 59th annual meeting of the German Foundry Owners' Association, the following Papers are to be presented:—

(1) Concerning the Properties of Various Types of Pig-iron of Different Origin, by Dr. Ing. Wagner, Volkingen.

(2) Growth of Cast Iron: (*a*) Results of previous investigations, by Dr. Ing. Bardenheuer, Düsseldorf, and (*b*) Results of recent experiments as to the influence of phosphorus, sulphur, nickel and chrome, by Director Sipp, Mannheim.

(3) Progress in the Use of Cast-iron Columns encased in Concrete, by Dr. Ing. Bauer, Vienna.

(4) Report on Activities of the German Non-Ferrous Foundry Association: (*a*) Melting losses, and (*b*) Scrap in non-ferrous foundries, by Herr Reiff, Hagen.

(5) Recent Opinions on Mechanical Properties of Castings, by Professor Dr. Thum, Darmstadt.

(6) The Hydraulic Method of Fettling Castings, by Professor U. Lohse, Hamburg.

(7) Importance of the Rhenish-Westfalian Foundry Industry, by Chief Eng. Langenohl, Gelsenkirchen.

These reports and Papers are to be read at meetings held at 27, Breite Strasse, Düsseldorf, on Wednesday and Thursday, September 4 and 5.

Book Review.

Human Engineering and Industrial Economy. By Lawrence A. Hartley, 1929. Obtainable from the National Founders' Association, 29, South La Salle Street, Chicago, U.S.A. Price 3 dollars.

Mr. Hartley is Director of Education to the National Founders' Association of America, and founders i: this country would, therefore, look to any work of his as likely to be of interest. The present interesting volume is intended, in his own words, to "serve as a source-book in human relations in industry" and "to reduce expense and friction resulting from needless supervision through increased interest in production and distribution and better understanding of the various human elements in every industrial situation." The book covers a great variety of subjects, of which the following chapter-headings will give some idea:—"The Economic Value of the Open Mind," "The Relation of Human Adaptability to Industrial Efficiency," "The Will to Work as an Economic Asset," "Moral Values in Machine Production," "Revolution and Evolution in Industry," "The Economic Value of Industrial Friendship." It will be seen from these examples that the book is not easily classifiable, although it partakes of the nature of economics, of sociology, and even at times of ethics; in fact, it belongs to that class of literature known in the United States as "inspirational," and which has no counterpart in this country. It is lavishly supplied with quotations, that range from Bulwer Lytton to Henry Ford; each chapter ends with a series of "Interest Questions" arising out of the text, and a number of specific reading references, and there is a full bibliography of books and periodicals at the end. These references are necessarily almost all American, even where they consist of extracts from standard English authors. Unfortunately, the whole scheme of the book is so closely bound up with the American conditions from which it springs, and so thoroughly inbued with the spirit that animates American industry, that its purpose, which we may assume to be that of stimulating the industrial worker to consider the why and the wherefore of industry, is necessarily almost entirely inoperative over here. At the same time, the book is of interest and value to the English reader because of the useful light it throws upon American industrial conditions. The illustrations in particular are very varied, covering works stores, apprentice classes, employees' outings, works hospitals, works cafeterias and other branches of activity. In the same way the text provides, although indirectly and by implication, much information on subjects that we over here would classify as personnel work, welfare work, co-partnership, and apprentice training. There is, however, one big difference. Every argument and every description is completed by the statement that it pays. English employers would probably endorse this experience, but they would not share the necessity under which their American confrères labour, namely, that of convincing their employees of the fact in order to persuade them to avail themselves of the facilities offered. Mr. Hartley's book is in more ways than one a striking illustration of the differences that do in fact exist between industrial conditions in the United States and in Great Britain.

The Brightside Foundry and Engineering Company, Limited, Newhall Iron and Engineering Works, Sheffield, have secured the order for their patent pig-iron-breaking machine from Messrs. Koninklijke Nederlandsche Hoogovens En Staalfabrieken, N.V., Holland, in connection with their blast-furnace extensions.

Random Shots.

Are you back at work yet? It's about time, you know. Even the cartoonists on the daily papers have picked up their pencils again, and we are no longer regaled with that useful set of untopical "back numbers" that has appeared every August in living memory. Haven't you ever noticed them? Ah, perhaps you are less observant than "Marksman"—and how fortunate for the poor hard-worked cartoonist that you are! Fortunate for "Marksman," too, although he does try to be rather less transparent about his own movements. It might be worth while to run a competition just to find out—a competition to see if anyone could tell, from internal evidence only, when and where "Marksman" took, is taking, or will take his holiday. As the chance of anyone giving the correct answer would be about one in ten million—(multiply the number of possible holiday resorts in the world by the number of weeks in the years to find out)—I could quite safely offer a handsome prize. . . . I must talk to my friend the Editor about this.

* * *

I have commented before now on the strange fact that September is as much the conference month as August is the holiday month. And not only in this country. I have lost count of the number of German technical organisations that are holding meetings in Düsseldorf during the run of the Foundry Exhibition there next month. This happens to be the example that interests me—and you—particularly, but it is typical, I assure you. Now why is it? Are these conferences so exhausting that we can only face them when we are fresh from the ocean ozone and the briny breezes? Or does it just happen to be a convenient time? I should like to know.

* * *

This kind of monthly localisation reminds me of the habit of representing the months of the year by scenes and symbols drawn from the cultivation of the soil—a habit that was prevalent in the Middle Ages, but one that has long since died a natural death. I am afraid that very few men to-day would instantly think of a particular month if they were confronted with a picture of reaping, or ploughing, or sowing. Nor does there seem to be any set of equivalent symbols that would convey the same meaning to the twentieth century man. The schoolboy would conceive of the year in terms of terms (oh, dear!), and holidays, the family man in terms of periods of heavy expenditure—holidays, Christmas, measle-time—the sportsman in terms of games, football, cricket, golf, with ski-ing and dirt-track racing to fill in. Society folk, I suppose, would think of June as London, August as Scotland, September as Biarritz, January as Switzerland—no, I'm not aristocratic enough to get beyond that! In other words, every man to-day has his own set of symbols for the months of the year. We are a far cry from the cultivation of the soil!

* * *

Albert Tells the World . . .

III. *What he thinks about Radio.*

"Too much jazz? Well, it's all a matter o' opinion. An' there's some says too many talks, an' some says too many 'ighbrows, an' some says too much broadcastin' altogether. Me? Well, I says, either you like radio, or you don't. If you don't, there's no call on you to listen, is there? An' if you do like it, before you begin to criticise this an' that an' the other, just you remember what it was like when there wasn't no radio at all, an' you be thankful for what you've got! Still, they might do a few more cup ties next winter. . . ."

Marksman.

Trade Talk.

The foremen and staff of the Grangemouth Dockyard Company, Limited, have presented Mr. J. Harvey, director, with a silver tea service on the occasion of his marriage.

Mr. J. Swallow, Midland representative of Messrs. Head, Wrightson & Company, Limited, Thornaby-on-Tees, has removed from Nunsfield House, Alvaston, Derby, to Hill Turrets, Parkhead, Sheffield.

Copperized Steel, Limited, 23, Westgate Chambers, Newport, Mon., owners of the European rights in the Watkins process of continuous sheet annealing, have opened a London office at 617, Australia House, Strand, W.C.2.

Contracts have been placed with Messrs. Scotts' Shipbuilding & Engineering Company, Limited, Greenock, by the Atlantic Refining Company, of Philadelphia, for two single-screw Diesel-electric oil tankers, each of about 8,900 tons gross.

Owing to an accident to a crane in the Gowanbank Foundry of Messrs. Cockburn & Company, Limited, Falkirk, Hector Baird M'Kinlay, a bath moulder, received severe abdominal injuries from which he died in the Falkirk Infirmary soon after admission.

Additional shipbuilding orders have been booked on the Tyne. Messrs. Palmers' Shipbuilding and Iron Company, Limited, Jarrow and Hebburn, have secured a contract for an 8,000-ton cargo vessel and engines for Messrs. F. Carrick & Company, Limited, Newcastle. Messrs. Swan, Hunter & Wigham Richardson, Limited, Wallsend, have booked a contract for a motor tanker of about 9,000 tons for Norwegian owners.

A shortage of labour is being experienced in the iron and steel industry in the North of France. It is estimated that about 20,000 men are required to fill the vacancies. The shortage is most noticeable in the heavy industries. Men are being recruited in Eastern Europe, and many have arrived lately from Poland and Yugoslavia. The influx of men is causing a shortage of houses, and many plant owners are compelled to build houses for their workers.

Messrs. Charles Connell & Company, Limited, Scotstoun, have launched the cargo steamer "Comedian," which they have built to the order of Messrs. T. & J. Harrison, Liverpool. The vessel is of 5,000 tons gross, and is fitted with the latest machinery for the rapid and efficient handling of cargo. The propelling machinery is to be of the triple-expansion type supplied by Messrs. David Rowan & Company, Limited, Glasgow.

The Horseley Bridge and Engineering Company, Limited, and its associated companies, Messrs. Thomas Piggott & Company, Limited, and Messrs. Guest, Keen & Piggotts, Limited, have opened a drawing office in London at 5, Victoria Street, Westminster, where a technical staff is employed in designing and estimating for all classes of structural steel and bridge work. The office is being run in conjunction with the chief London office of these companies at 11, Victoria Street.

Messrs. Geo. G. Blackwell, Sons & Company, Limited, Blackwell's Metallurgical Works, Limited, and the British Thermit Company, Limited, of The Albany, Liverpool, announce that as the manufacturing side of their business has developed they have suffered inconvenience owing to their offices being at a distance from their works, warehouse, and shipping depôts. They have at present under construction offices at their Garston works, and hope to have these ready for occupation in a few weeks' time.

Messrs. Harland & Wolff, Limited, have launched from their Govan yard the motor cargo vessel "Kufra," which they have built to the order of the Moss Line, Limited. The vessel is of the shelter-deck type, with bridge and boat decks, 330 ft. long and 2,650 tons gross. The propelling machinery is being supplied by Messrs. John G. Kincaid & Company, Greenock, and consists of single-acting engines of Harland-B. and W. type, working on the four-stroke cycle and capable of developing 2,050 b.h.p.

Messrs. David MacBrayne (1928), Limited, have now placed orders for another two of the five vessels which they undertook to have built in accordance with their mail and passenger service agreement with the Post Office. These vessels will be built by the Ardrossan Dockyard, Limited, Ardrossan, and will be fitted with Gardner engines of the heavy-oil cold-starting type of 600 b.h.p. aggregate for each ship and of similar construction to those to be fitted in the Columbian gunboats which Messrs. Yarrow & Company, Limited, Scotstoun, are building.

The Wellman Smith Owen Engineering Corporation, Limited, have received from the Koppers Coke Oven Company, Limited, Sheffield, a contract for the supply of the whole of the oven-handling machinery required in connection with the large installation of coke ovens to be built by the Koppers Company at the Beckton Works of the Gas Light and Coke Company. The machinery ordered comprises two Wellman combined coke-pusher, coal-leveller and door-extractor machines, two three-hopper type coal-charging cars, two combined door-extractor and coke-guide machines, two coke-quenching cars, and one electric locomotive.

A comprehensive research into the industrial applications of tin, including its properties as a preventive of corrosion and its economic use in the production of efficient high-speed bearings, is to be undertaken by the Tin Industrial Applications Committee, which was formed recently in co-operation with the British Non-Ferrous Metals Research Association. The secretary of the Committee stated in an interview that, although tin is the oldest of all metals to be used as an alloy, no comprehensive research has ever been made into its properties. American and British users of tin are taking an active interest in the new Committee.

Messrs. Alfred Herbert, Limited, Coventry, have secured an order for nine Atritors, each of 4 tons hourly capacity, for the Amsterdam electricity authorities, thus completing an installation of 25 Atritors for this power station. This will be the largest unit pulveriser installation on the Continent. Orders have also been received from the Worcester, Rotherham and Newport Corporations. The firm's American licensees, the Riley Stoker Corporation, have secured an order for four Atritors, each of 7 tons hourly capacity, for the Cahokia Station of the St. Louis Electric Light and Power Company, as well as orders from the Carnegie Steel Company, Pittsburgh, and other manufacturing concerns in the United States.

The British Swiss International Corporation, Limited, have paid to the Government of the Union of South Africa the sum of £302,000, being the estimated cost of the railway now in course of construction between Koopmansfontein and Postmasburg, Cape Province of South Africa. In the same connection the Manganese Corporation (1929), Limited, has deposited with the Union Government securities of the Government of the Union of South Africa totalling £100,000. The Manganese Corporation, it will be remembered, was formed by the British Swiss International Corporation to develop the deposits of manganese at Postmasburg. Its working capital, amounting to £400,000, has been privately subscribed.

The total number of unemployed members of the Amalgamated Engineering Union in Scottish areas increased in July from 10,888 to 11,053. Mr. Dewar, the Edinburgh delegate, reports that the usual suspensions and dismissals have marked the holiday period in a number of shops, and, with ship-repairing work at a low ebb, the set-back has increased the unemployment figure to a higher level than has been experienced since the new year. Indications point, however, to the dislocation being of a temporary nature. The Glasgow delegate, Mr. Luckhurst, reports that trade showed a decline in the early part of the month owing to the holiday season. At Paisley, Mr. Storrie reports that there is no definite change to record in his area, except a slight falling-off on account of holidays. At Dundee, according to Mr. Maloney, the divisional delegate, prospects are distinctly more promising than during recent months, and there is an immediate prospect of increased employment for fitters in textile engineering.

New Government contracts listed in the "Ministry of Labour Gazette" include the following:—Admiralty: Galvanised corrugated sheets, Walker Bros., Limited, Walsall; cylindrical boilers, R. & W. Hawthorn, Leslie & Company, Limited, Newcastle-on-Tyne; cast-iron retorts, Carron Company, Falkirk; lead sheet and pipe, Locke, Blackett & Company, Limited, Newcastle-on-Tyne. War Office: Steel bars, John Brown & Company, Limited, Sheffield; mild steel, Whitehead Iron and Steel Company, Limited, Tredegar; steel rails and fishplates, Guest, Keen & Nettlefolds, Limited, Dowlais; steel rounds, English Steel Corporation, Limited, Sheffield. Crown Agents for the Colonies: Locomotives, Hunslett Engine Company, Limited, Leeds; R. Stephenson & Company, Limited, Darlington; steel tyres, H. Bessemer & Company, Limited, Sheffield; Brown Bayley's Steelworks, Limited, Sheffield; wagons, Metropolitan-Cammell Carriage, Wagon Finance Company, Limited, Saltley, Birmingham; wheels and axles, John Baker & Company (Rotherham), Rotherham.

The Integra Company, Limited, 183, Broad Street, Birmingham (agents for the Leeds Northrup Company, Philadelphia), have received an order from Messrs. Henry Ford & Son, Limited, Cork, for 24 L. & N. potentiometer recorders, fitted with signalling lamps and deviation indicators, which are to be used for the temperature control of the heat-treatment plant. The signalling lamps and deviation indicators will be installed in front of each furnace. The panel of three signalling lamps, red, white and blue, will give a five-light combination—high, normal and high, normal, normal and low, and low. The recorders will be situated in the metallurgist's office, at a distance from the heat-treatment shop. The Integra Company, Limited, have also received an order from Petroleum Refineries, Limited, for four six-point and two four-point L. & N. potentiometer recorders, and one double-range wall-type L. & N. indicator. This equipment will be used in connection with the new cracking plant of Petroleum Refineries, Limited, which is being installed at Killingholme.

Personal.

Mr. William C. Lusk has been elected chairman of the British Thomson-Houston Company, Limited, and has resigned the position of managing director. Mr. Lusk has also been appointed deputy chairman of Associated Electrical Industries, Limited.

Mr. John Fraser and Mr. William Ellis Hughes have been elected directors of Messrs. A. G. Kidston & Company, Limited, iron and steel merchants and exporters, of Glasgow and London. Both gentlemen have been connected with the firm for upwards of 30 years.

Will.

Millington, E. S., managing director of Messrs. Thomas Sheldon & Company, Limited, Springvale Foundry, Ettingshall, Wolverhampton £23,233

Obituary.

Mr. James Dickson, chairman of Messrs. Henry Rossell & Company, Limited, steel manufacturers, Sheffield, died recently.

The death has occurred at his residence in Aberdeen of Mr. Francis Coutts, partner and manager of the engineering department of Messrs. Hall, Russell & Company, Limited.

Mr. S. Archie D. Webster, whose death occurred at Falkirk on August 17, was a native of Newcastle, but went to Falkirk as draughtsman with the Falkirk Iron Company, Limited, many years ago. Latterly he held a similar position with Messrs. R. & A. Main, Limited, Gothic Iron Works.

The death occurred on August 19, at his home in Aberdeen, of Mr. Arthur Farquhar, Bucksburn Engineering Works, Aberdeen, at the age of 52. Mr. Farquhar succeeded his father in business over twenty years ago, and was well known in engineering circles as the manufacturer of Farquhar's patent engine packing.

New Companies.

Amalgamated Brassfounders, Limited, 123b, Church Street, Croydon.—Capital £500. Directors: P. N. Dingley, M. Blakeway and G. Sizen.

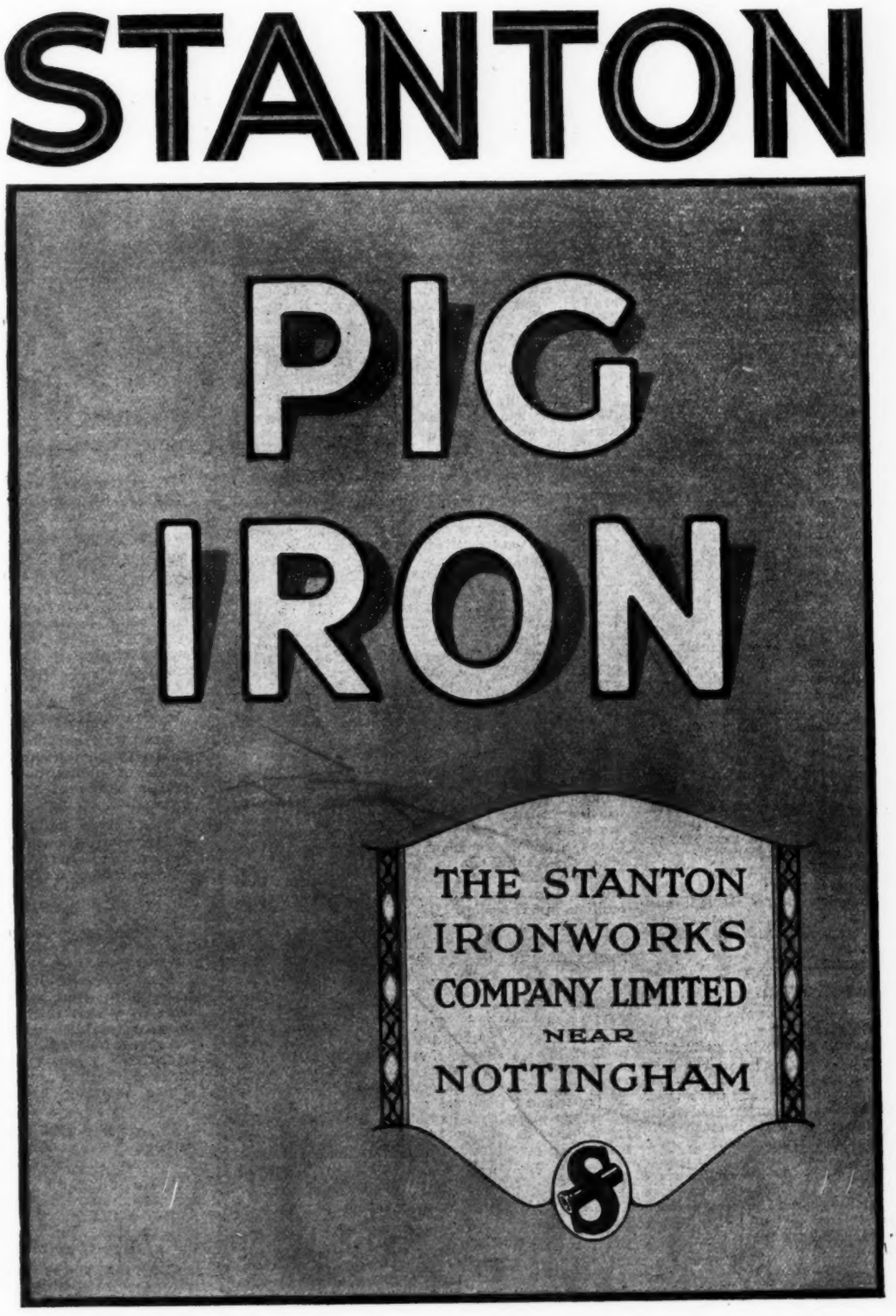
Coventry Chromium Plating Company, Limited.—Capital £1,000. Directors: C. G. Tysoe, S. Tysoe, 94, Godiva Street, Coventry; and G. H. Tysoe.

H. Stockwell & Company, Limited, 401-4, Corn Exchange Buildings, Hanging Ditch, Manchester.—Capital £5,000. Iron and steel merchants, etc. Directors: H. Stockwell and B. Stockwell.

Reports and Dividends.

W. Canning & Company, Limited.—Interim dividend at the rate of 5 per cent. per annum, less tax.

Brightside Foundry & Engineering Company, Limited.—Profit, £9,365; brought in, £7,234; preference dividend, £2,250; dividend of 5 per cent. on the ordinary shares, £4,000; carried forward, £10,350.


STANTON
PIG
IRON
THE STANTON
IRONWORKS
COMPANY LIMITED
NEAR
NOTTINGHAM

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—With the completion last week-end of the local holiday season, business in the Cleveland iron markets may be confidently expected to take a more active turn, and already signs are apparent of less unsatisfactory conditions prevailing in the near future, both as regards volume of sales and an increase of production on a scale permitting earlier deliveries. This is especially the case as regards the scarcity of foundry grades, which is now being gradually overcome, makers having been able to overtake arrears of delivery, and the improvement is reflected in the fact that it is now possible to buy Cleveland pig-iron for September delivery. It is true that the tonnage on offer is by no means unlimited. On the other hand, some makers are still unable to quote for delivery before October. But consumers wanting reasonable quantities can now be supplied, and business for later periods can be freely placed. Consumers, however, see no reason for precipitancy, and, as the outlook should be clearer next month, they are in no haste to commit themselves. Meanwhile, current quotations remain as follow:—No. 1 Cleveland foundry iron, 75s. per ton; No. 3 G.M.B., 72s. 6d.; No. 4 foundry, 71s. 6d.; No. 4 forge, 71s. per ton.

For reasons stated more fully above, conditions in the market for East Coast hematite continue still subject to seasonal influences, and, although the trend of prices is upward, the movement is far too slow for the makers, who are selling substantially below cost price. The current output is passing fairly promptly into consumption, but home and Continental consumers are not buying very far ahead. Current quotations are unchanged at 75s. 6d. per ton for mixed numbers, with No. 1 quality at 76s. On the North-West Coast, Bessemer mixed numbers are still quoted at 75s per ton, at works.

LANCASHIRE.—Few complaints are expressed by sellers in local markets for foundry pig as regards the matter of deliveries, which are being taken with commendable regularity by consumers in a satisfactory aggregate tonnage. Prices also are firmly held about as follow:—Derbyshire No. 3, 74s. 6d.; Staffordshire, 75s. 6d.; with Scottish brands at 91s. 6d. to 92s. 6d., all per ton delivered equal Manchester.

THE MIDLANDS.—Consumers of foundry iron in this area are now taking slightly more interest in the local markets, and business, though still on the quiet side, may be expected to brighten up considerably in the approaching September. Prices, however, remain practically stationary, as follow:—Northants No. 3, 72s. 6d.; Derbyshire No. 3, 76s.; North Staffordshire, 77s.; with Scotch foundry at about 94s. 6d., all per ton delivered local stations.

SCOTLAND.—Demand for Scotch pig-iron continues slow, and little fresh business is circulating. The large inquiry which was recently in the market for the light-castings founders did not result in business, the buyers deciding not to purchase just yet. Prices are firm on the basis of 76s. for No. 3 Scotch foundry, f.o.t. furnaces.

Finished Iron.

The demand for Staffordshire marked bars is showing improvement, and the mills making this class of bar are now very well occupied. The price is £12 at works. Unfortunately, the same position does not obtain with regard to crown and the cheaper bars. The works manufacturing these grades are anything but well situated, and there is much competition for the business offering. Few, if any, of the mills are fully occupied. Crown iron quotations vary from £9 15s. to £10 5s., the Staffordshire works quoting £10 to £10 5s. Nut and bolt iron is quoted at £9 5s. and upwards, but the demand is extremely poor, to a large extent owing to the competition from the Belgian works.

Steel.

In the Sheffield market business continues quiet, and no expansion is likely for another fortnight at least. Sales of basic billets are the only feature of note. Acid billets are almost entirely neglected. Prices are unchanged. The demand for finished steel has been weak for some time. Inquiry, however, has become more active of late, and this may be an indication that an improvement is at hand, as buying by several overseas markets is overdue. The tinplate market has been fairly active of late, with quotations steady at 18s. 3d. to 18s. 6d. basis, net cash, f.o.t. Welsh ports.

Scrap.

Only a moderate volume of business is reported from the various centres of the scrap metal trade, but values of the leading lines are well maintained. On the North-East Coast the foundries are expected to come on to the market very soon for supplies of heavy cast iron, and an advance would create no surprise, although merchants are still prepared to sell ordinary quality at 66s. 6d. and machinery quality in handy sizes at 68s. 6d. In Scotland ordinary heavy cast-iron scrap suitable for steelworks is still quoted at 62s. 6d., and pieces suitable for foundries at 64s. to 65s. Machinery cast-iron scrap to the same specification is quoted at 67s. 6d. to 70s., old cast-iron railway chairs at 66s. 6d. to 67s. 6d., and light cast iron at 60s., all per ton delivered f.o.t. consumers' works.

Metals.

Copper.—Only a few shillings each way have marked the fluctuations in values of warrant copper during the past few weeks, the market position being practically stabilised at about £73 10s., with an upward tendency. Continental reports are fairly satisfactory, and the volume of orders has improved, while offerings at concessions on the official price have almost ceased. Purchases, however, would still appear to be confined to actual requirements or against contracts received by manufacturers.

Closing quotations are :—

Cash.—Thursday, £73 18s. 9d. to £74; Friday, £73 17s. 6d. to £74; Monday, £73 16s. 3d. to £73 18s. 9d.; Tuesday, £73 15s. to £73 17s. 6d.; Wednesday, £73 15s. to £73 17s. 6d.

Three Months.—Thursday, £74 13s. 9d. to £74 15s.; Friday, £74 10s. to £74 11s. 3d.; Monday, £74 10s. to £74 12s. 6d.; Tuesday, £74 10s. to £74 12s. 6d.; Wednesday, £74 11s. 3d. to £74 12s. 6d.

Tin.—The recovery in tin values, previously recorded, continues to make steady progress, last week's closing prices showing a further advance, while American advices report quite a satisfactory trade in that country. On the London market, although the volume of actual business transacted has been smaller in volume and speculative interest has suffered a temporary check, the undertone continues firm and confident. During the past fortnight some shipments to America from the United Kingdom stocks have taken place, which should provide some measure of relief to the overstocked position in this country.

Official closing prices :—

Cash.—Thursday, £209 15s. to £209 17s. 6d.; Friday, £210 10s. to £210 12s. 6d.; Monday, £209 5s. to £209 10s.; Tuesday, £208 7s. 6d. to £208 10s.; Wednesday, £208 to £208 5s.

Three Months. — Thursday, £213 10s. to £213 12s. 6d.; Friday, £214 to £214 2s. 6d.; Monday, £213 7s. 6d. to £213 10s.; Tuesday, £212 7s. 6d. to £212 10s.; Wednesday, £212 to £212 5s.

Spelter.—Demand for spelter is on a very small scale, and values still mark a declining tendency. At the moment there are no indications of any improvement in the near future, and with the galvanising industry in this country in its present dull state everything points to a further decline in values, as stocks on the Continent continue to remain excessive.

Daily quotations are :—

Ordinary.—Thursday, £24 18s. 9d.; Friday, £25 1s. 3d.; Monday, £25 1s. 3d.; Tuesday, £24 17s. 6d.; Wednesday, £24 16s. 3d.

Lead.—New arrangements having been completed, it is understood, for centralising sales of soft foreign pig between leading Australian and American interests in connection with acquiring control of the European markets, it is now expected that prices may become more stabilised, to the advantage of all concerned, and conditions are at present much steadier than for some time past.

Prices have been :—

Soft Foreign Prompt.—Thursday, £23 2s. 6d.; Friday, £23 2s. 6d.; Monday, £23 2s. 6d.; Tuesday, £23 6s. 3d.; Wednesday, £23 6s. 3d.

Students' Corner.

Q.—What is required to produce a ton of pig-iron ?

A.—To obtain 1 ton of pig-iron from Cleveland ironstone requires 48 cwts. of calcined iron ore, 12 cwts. of limestone, 20 cwts. of good coke, and 100 cwts. of hot blast. In addition, there would be produced 30 cwts. of slag and 130 cwts. of waste gases.

Q.—What are the constituents of cast iron ?

A.—The following table shows the symbols, atomic weights, and specific gravities of the constituents of cast iron.

Name.	Symbol.	Atomic weight.	Specific gravity.
Phosphorus ..	P	31.00	1.8
Sulphur ..	S	32.00	1.97
Carbon (graphite)	C (Gr)	12.00	2.20
Silicon	Si	28.00	2.49
Manganese ..	Mn	55.00	8.00
Iron	Fe	56.00	7.86
White iron ..	—	—	7.55
Grey iron ..	—	—	6.85

Grey iron melts at 1,250 deg. C.
White iron melts at 1,150 deg. C.

Q.—What does symbol — specific gravity and atomic weights of the constituents convey ?

A.—Symbols.—It has been found convenient to represent each element by the initial letter or letters of its Latin name. Specific gravity is the number which expresses the weight of a body compared with that of an equal bulk of water. Thus, taking the specific gravity of two extremes, gold is 19.3 and aluminium is 2.65.

Atomic Weights.—Atoms were supposed to be the smallest possible particles of elements, hence indivisable, which can unite to form complexes termed molecules.

[Sir Oliver Lodge now tells us that electrons are thousands of times smaller than atoms. In comparison, a mountain may represent an atom, and an electron a mole-hill.]

Q.—What information can be obtained upon grades of iron ?

A.—Grades of iron in the pig form differ somewhat according to the district in which they are made, but all furnace plants grade their pig-iron numbers according to fracture and analysis. A No. 1 grade of any blast-furnace plant is always the softest, and shows a very open grain fracture. Physically it is a very weak iron.

A No. 2 grade of pig-iron shows a rather closer fracture than a No. 1 grade, and is a little stronger physically.

A No. 3 grade shows a still closer fracture than a No. 2 and is also stronger. A No. 4 the fracture is now becoming closely knit, and much stronger than the previous numbers.

A No. 5 grade is very dense and strong; its fracture is closely knit. No. 6 grade is a mottled iron—that is, midway between grey and white. It is very dense and hard.

No. 7 is a white iron. It is granular in fracture, white in colour, extremely hard and brittle, hence unmachinable.

TRADE MARK.

"SERVICE BCM/GX FIRST"

"SANDS MAY COME
and
SANDS MAY GO"
but
"YORKSHIRE SAND"
GOES ON FOR EVER!

"YORKSHIRE SAND" THE STEELMOULDER'S FRIEND IS BETTER THAN EVER.

New and Scientific Mixing Processes have recently been perfected and installed, and our works equipped with Milling plant of the most efficient type, specially made for the work of sand preparation.

UNLIKE BELGIAN SANDS

—one thing to-day and another to-morrow—"Yorkshire Sand" does not vary in either grain size or percentage of bond and it is absolutely free from stones and lumps of clay,

AND

IT IS CHEAPER IN USE THAN ANY FOREIGN SAND.

The whole country is suffering from unemployment due principally to the unrestricted importation of unnecessary foreign goods—why not nail your colours to the mast and adopt the slogan—

"BUY BRITISH STEEL CASTINGS AND BRITISH SANDS!"

If the proposition presents any difficulty, send for us to talk it over and we will undertake to meet your reasonable views. If you use foreign sand, you can't legitimately complain of engineers using foreign castings.

We don't sell foreign castings and deprive you of work. We support British Institutions and trade and technical associations. We live here and pay British rates and taxes. We help to buy your output.

We don't ask for orders for 500-ton lots (payment against B/L), we sell in truck loads and wait for our money—sometimes three or four months (sometimes we never get it at all). We are always here at the end of a wire for advice, help or support. If you receive from us any goods you don't like—send them back.

We give prompt delivery of Yorkshire Sand and every ton lot of it you buy finds work for Englishmen and Scotsmen and helps to improve your own business by circulating more money in the country, and reducing the amount sent abroad for needless foreign purchases.—Think it over and you will see we are right.

◈ ◈ ◈

GENERAL REFRACTORIES, LTD.

Telephone: 22311.

SHEFFIELD.

Telegrams: "GENEFRAX, SHEFFIELD."

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	73	15	0
Three months	74	11	3
Electrolytic	84	5	0
Tough	77	5	0
Best selected	77	15	0
Sheets	110	0	0
India	94	5	0
Wire bars	84	12	6
Do. Aug.	84	12	6
Do. Sept.	84	12	6
Ingot bars	84	12	6
H.C. wire rods	86	15	0
Off. av. cash, July	72	3	11 13/20
Do. 3 mths., July	72	15	3 6/13
Do., Sttlmnt., July	72	3	8 6/13
Do., Electro, July	84	5	9 15/13
Do., B.S., July	75	11	4 3/13
Aver. spot price, copper, July	72	3	11 13/20
Do. wire bars, July	84	10	9 3/13
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			11½d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	14½d.
Rods, drawn	12½d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	11½d.
Wire	11½d.
Rolled metal	10½d.
Yellow metal rods	8d.
Do. 4 × 4 Squares	8½d.
Do. 4 × 3 Sheets	9d.

TIN.

	£	s.	d.
Standard cash	208	0	0
Three months	212	0	0
English	209	0	0
Bars	210	10	0
Straits	212	7	6
Australian	210	12	6
Eastern	217	10	0
Banca	Nominal		
Off. av. cash, July	209	11	6 6/13
Do., 3 mths., July	213	0	1 7/13
Do., Sttlmt., July	209	11	6 6/13
Aver. spot, July	209	11	6 6/13

SPELTER.

	£	s.	d.
Ordinary	24	16	3
Remelted	22	10	0
Hard	20	15	0
Electro 99.9	26	17	6
English	25	5	0
India	21	10	0
Zinc dust (Nom.)	34	10	0
Zinc ashes	8	15	0
Off. aver., July	25	7	6 15/26
Aver., spot, July	25	6	7 13/13

LEAD.

	£	s.	d.
Soft foreign ppt.	23	6	3
English	24	10	0
Off. average, July	22	16	10 12/13
Average spot, July	22	16	2 3/13

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	34	10	0
Do. V.M. ex-whf.	32	12	6
Rods	40	0	0
Boiler plates	30	10	0
Battery plates	31	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	50	5	0
Chinese	32	15	0
Crude	Nominal		

QUICKSILVER.

	£	s.	d.
Quicksilver	22	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	15	0
45/50%	12	0	0
75%	19	10	0
Ferro-vanadium—			
35/50%	12/10 lb. Va.		
Ferro-molybdenum—			
70/75% c. free	4/- lb. Mo.		
Ferro-titanium—			
23/25% carbonless	11d. lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%, c. fr.	3/3½ lb.		
Tungsten metal powder—			
98/99%	3/6½ lb.		
Ferro-chrome—			
2/4% car.	£32	10	0
4/6% car.	£23	7	0
6/8% car.	£22	10	0
8/10% car.	£22	0	0
Ferro-chrome—			
Max. 2% car.	£33	0	0
Max. 1% car.	£37	12	6
Max. 0·70% car.	£40	0	0
70% carbonless	1/2 lb.		
Nickel—99% cubes, or pellets	£175	0	0
Ferro-cobalt	9/4 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	2/6 lb.		
Ferro-manganese (net)—			
76/80% loose	£13	15	0
76/80% packed	£14	15	0
76/80% export	£14	0	0
Metallic manganese—			
94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finshed bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ⅛ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel				3	16	6
Bundled steel and shrngs.	3	12	6 to	3	16	0
Mixed iron and steel	3	11	0 to	3	12	6
Heavy cast iron	2	17	6 to	3	0	0
Good machinery for foundries				3	5	0
Cleveland—						
Heavy steel				3	5	0
Steel turnings				2	17	6
Cast iron borings				2	16	0
Heavy forge				3	17	6
W.I. piling scrap				3	11	6
Cast-iron scrap	3	7	0 to	3	8	6
Lancashire—						
Cast-iron scrap	3	2	6 to	3	10	0
Hvy. wrought				3	17	6
Steel turnings				3	0	0
Scotland—						
Heavy steel				3	17	0
Cast-iron borings				2	14	6
Wrought-iron piling				3	12	6
Heavy machinery				3	8	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	64	0	0
Brass	42	0	0
Lead (less usual draft)	20	10	0
Tea lead	16	10	0
Zinc	16	10	0
New aluminium cuttings	68	0	0
Braziery copper	56	0	0
Gunmetal	57	0	0
Hollow pewter	155	0	0
Shaped black pewter	110	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	76/-
Hematite M/Nos.	75/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
„ d/d Birm.	92/-
Midlands—	
Staffs. common*	—
„ No. 4 forge*	73/-
„ No. 3 fdry*	77/-
Shrops. basic	—
„ Cold blast, ord.	—
„ „ roll iron	—
Northants forge*	68/6
„ fdry. No. 3*	72/6
Derbyshire forge*	72/-
„ fdry. No. 3*	76/-
„ basic*	—

* d/d Black Country dist.

Scotland—	
Foundry No. 1	78/6
„ No. 3	76/-
Hem. M/Nos.	80/-
Sheffield (d/d district)—	
Derby forge	67/-
„ fdry. No. 3	71/-
Lincs. forge	—
„ fdry. No. 3	74/6
E.C. hematite	86/-
W.C. hematite	87/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 3	74/6
Northants foundry No. 3	—
Dalzell, No 3 (special)	102/6 to 105/-
Summerlee, No. 3	92/6
Glengarnock, No. 3	—
Gartsherrie, No. 3	92/6
Monkland, No. 3	92/6
Shotts, No. 3	92/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.				10	15	0
Nut and bolt iron				9	5	0
Hoops	11	0	0 to	11	10	0
Marked bars (Staffs) f.o.t.				12	0	0
Gas strip	11	0	0 to	11	10	0
Bolts and nuts, ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates	8	12	6 to	8	17	6
Boiler plts.	9	12	6 to	10	10	0
Chequer plts.				10	12	6
Angles				8	2	6
Tees				9	2	6
Joists				8	2	6
Rounds and squares, 3 in. to 5½ in.				9	2	6
Rounds under 3 in. to ¾ in. (Untested)				8	0	0
				and upwards		
Flats, over 5 in. wide and up				8	7	6
Flats, 5 in. to 1½ in.				7	17	6
Rails, heavy				8	10	0
Fishplates				12	10	0
Hoops (Staffs)	10	0	0 to	10	10	0
Black sheets, 24g.	10	5	0 to	10	10	0
Galv.cor.shts., 24g.	13	5	0 to	13	10	0
Galv. fencing wire 8g. plain				12	0	0
Billets, soft	6	7	6 to	6	15	0
Billets, hard	7	10	0 to	8	0	0
Sheet bars				6	5	0
Tin bars				6	5	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9½
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	24/- to 27/6
„ furnace	21/- to 24/-
Durham and North.	
„ foundry	21/- to 21/6
„ furnace	19/6
Midlands, foundry	—
„ furnace	20/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/4½
„	28×20 „	37/-
„	20×10 „	26/9
„	18½×14 „	19/6
C.W.	20×14 „	15/3
„	28×20 „	33/6
„	20×10 „	22/6
„	18½×14 „	16/-
Terneplates	28×20 box basis f.o.b.	33/6 per

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6 0 0 to	£7 10 0
Bars, hammered, basis	£17 10 0 to	£18 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to	£16 15 0
Blooms	£10 0 0 to	£12 0 0
Keg steel	£32 0 0 to	£33 0 0
Faggot steel	£20 0 0 to	£24 0 0
Bars and rods, dead soft, steel	£10 0 0 to	£14 0 0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.
Over ½ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	65%	47½%
Water	61¼%	42½%
Steam	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Aug. 22	..	73	18	9	inc.	3/9
„ 23	..	73	17	6	dec.	1/3
„ 26	..	73	16	3	„	1/3
„ 27	..	73	15	0	„	1/3
„ 28	..	73	15	0	No	change

Electrolytic Copper.

		£	s.	d.		
Aug. 22	..	84	5	0	No	change
„ 23	..	84	5	0	„	„
„ 26	..	84	5	0	„	„
„ 27	..	84	5	0	„	„
„ 28	..	84	5	0	„	„

Standard Tin (cash).

		£	s.	d.		
Aug. 22	..	209	15	0	inc.	27/6
„ 23	..	210	10	0	„	15/-
„ 26	..	209	5	0	dec.	25/-
„ 27	..	208	7	6	„	17/6
„ 28	..	208	0	0	„	7/6

Tin (English ingots).

		£	s.	d.			
Aug. 22	..	210	0	0	inc.	20/-	
„ 23	..	211	0	0	„	20/-	
„ 26	..	209	10	0	dec.	30/-	
„ 27	..	208	10	0	„	20/-	
„ 28	..	209	0	0	inc.	10/-	

Zinc Sheets (English).

		£	s.	d.		
Aug. 22	..	34	10	0	No	change
„ 23	..	34	10	0	„	„
„ 26	..	34	10	0	„	„
„ 27	..	34	10	0	„	„
„ 28	..	34	10	0	„	„

Spelter (ordinary).

		£	s.	d.		
Aug. 22	..	24	18	9	No	change
„ 23	..	25	1	3	inc.	2/6
„ 26	..	25	1	3	No	change
„ 27	..	24	17	6	dec.	3/9
„ 28	..	24	16	3	„	1/3

Lead (English).

		£	s.	d.		
Aug. 22	..	24	10	0	inc.	5/-
„ 23	..	24	10	0	No	change
„ 26	..	24	10	0	„	„
„ 27	..	24	10	0	„	„
„ 28	..	24	15	0	inc.	5/-

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1887	37 5	35 10	34 4	34 4	34 1	34 10	34 4	34 5	33 9	31 10	31 8	33 6	34 2
1888	32 2	31 1	31 5	31 9	30 11	31 5	32 4	33 5	34 8	34 2	33 11	33 10	32 7
1889	33 8	35 0	37 5	38 9	38 6	37 10	40 1	43 4	44 1	51 5	64 7	61 1	43 10
1890	60 3	53 1	51 0	47 4	42 2	41 5	43 2	45 7	47 9	47 10	47 4	43 1	47 6
1891	42 1	41 10	39 9	38 7	40 9	41 0	40 8	39 8	40 4	39 11	38 8	38 1	40 1
1892	37 7	35 7	36 10	37 10	39 2	40 11	39 11	39 10	40 0	38 6	37 6	37 4	38 5
1893	36 0	34 3	34 4	34 2	33 10	34 8	35 3	35 5	35 4	34 8	34 7	35 9	34 10
1894	35 8	35 11	36 1	36 1	35 5	35 5	35 5	35 11	36 6	35 8	35 8	35 1	35 9
1895	34 7	34 4	34 4	34 8	35 6	35 2	36 1	37 1	38 10	38 6	37 11	37 6	36 3
1896	37 3	38 4	38 7	38 1	37 4	37 4	36 11	36 11	37 11	39 2	40 5	40 5	38 3
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 9	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 6
1907	60 4	56 6	54 10	56 0	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 6½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	47 4½	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	99 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 1½	97 0	100 0	100 0	110 6½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	70 0	70 0	70 0	72 6	75 10½	86 7½	90 0	93 10½	117 10	120 0	99 0	86 3
1927	85 0	83 1½	81 0	80 0	73 9	70 0	70 0	68 9	67 6	67 6	66 10½	65 0	73 2½
1928	65 0	65 0	65 6	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	66 0	65 9½
1929	66 0	66 9	67 0	68 1½	69 5	71 10½	72 9	—	—	—	—	—	—

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Sixty Horizontal Double-geared STEAM WINCHES (by Clarke Chapman) having cyls. 4½ in. dia. x 6 in. stroke; drum 22 in. dia. x 20 in. wide; brake.

Two LOCO. TYPE BOILERS, 11 ft. 6 in. long, barrel 2 ft. 8 in., reinsurable 170 lbs. pressure.

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